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CHEMICAL ANALYSIS OF SAMPLES FROM INTEROCEANIC CANAL ROUTE 17

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Abstract

This report contains data on the chemical analysis of core samples taken along the Atlantic-Pacific Interoceanic Canal Route 17. Route 17 in Panama is one of the principal routes now being considered for excavation of a canal by nuclear means.

This report contains a brief discussion of sampling procedures, analytical methods, sources of contamination, and the accuracy of analytical results. Lawrence Radiation Laboratory analyzed each of the samples for 84 constituents and a U. S. Army Corps of Engineers laboratory analyzed the samples for major elements. Four sets of analyses from the two laboratories are compared, and the significance of the comparisons is discussed.

Introduction

Chemical analyses were obtained for 39 core samples taken along the Atlantic-Pacific Interoceanic Canal Route 17. These analyses were obtained in support of the Atlantic-Pacific Interoceanic Canal Study Commission. Figure 1 is the map of the route showing the location of the core holes and an outline of the geology of the area.

Chemical analyses obtained under the direction of Lawrence Radiation Laboratory for 84 constituents in each of 39 core samples are given in Appendix A. Appendix B contains the major element analyses obtained by the U. S. Army Engineering Division Laboratory, South Atlantic Corps of Engineers (Corps of Engineers), Marietta, Georgia.[1]

[1] A. G. Sutton, Jr., Subsurface Geology Data Collection, Raw Data— Laboratory Results, Atlantic-Pacific Interoceanic Canal Study Commission, Balboa Heights, Canal Zone, Memorandum IOCS-FD-60 (1968), Part IV, Chemical Tests, Route 17.

Sampling

Core samples were taken under the direction of the U. S. Army Corps of Engineers. Bentonite mud was used as a coolant for the drill bits. Cores were protected from water loss in several ways, which included dipping the bare core in paraffin, wrapping the core in cloth and dipping in paraffin, wrapping in plastic

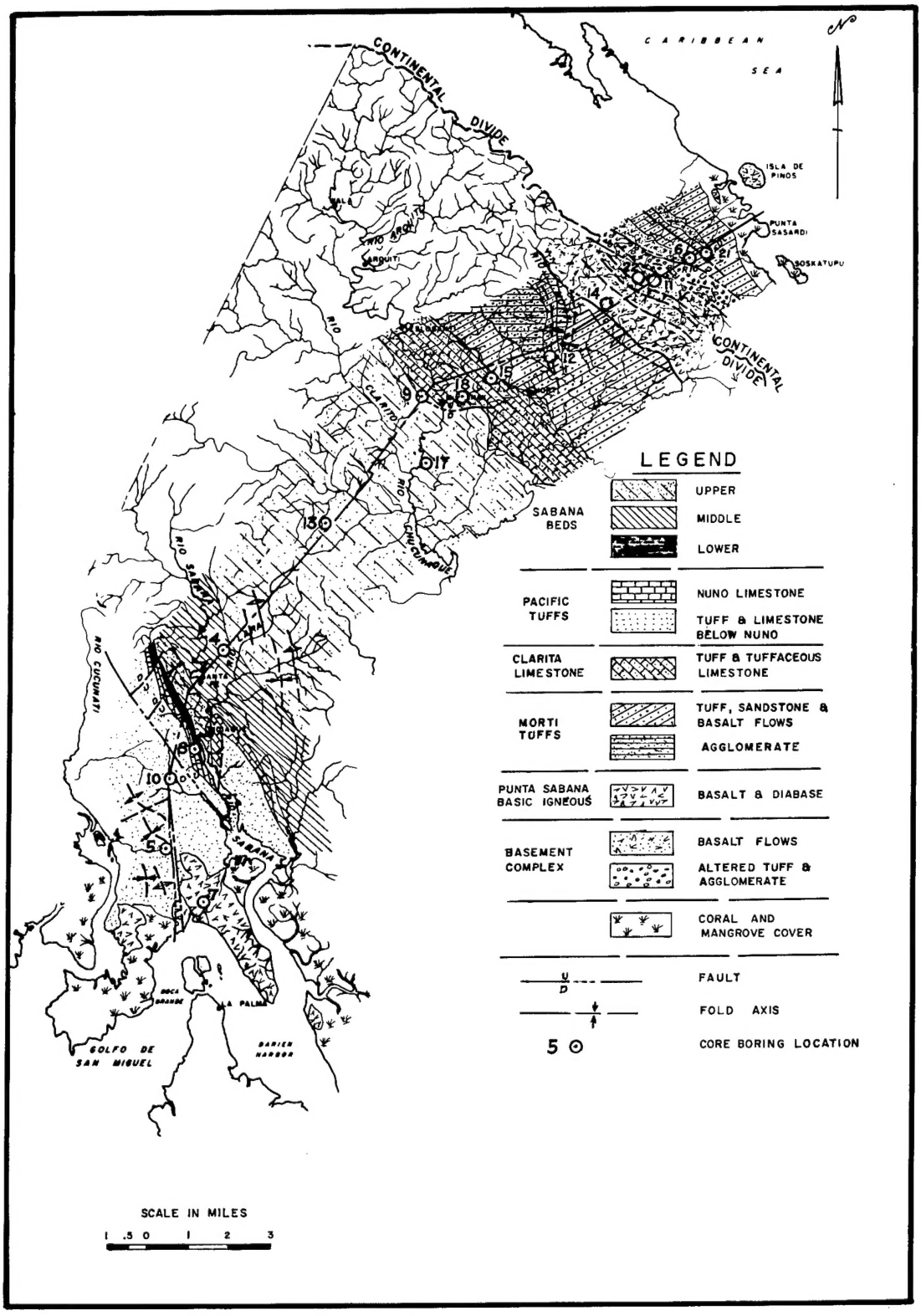

Fig. 1. Geologic map of Atlantic and Pacific Interoceanic Canal Route 17.

and dipping in paraffin, and wrapping in aluminum foil and dipping in paraffin.

The criteria applied in selecting core samples for chemical analysis were as follows[2]:

1. Select approximately four samples for each major lithologic type likely to occur at shot depths along the Route 17 alignment. (Actual number of samples taken for each rock type ranged from two to seven, depending upon the relative importance of that lithology in the overall stratigraphic section and the degree of compositional variability due to facies changes and/or alteration.)
2. Samples selected should reflect the range of compositional variations within each lithologic type due to facies changes and/or alteration.
3. At least one sample should be taken from each borehole to facilitate recognition of possible compositional changes on a regional scale.
4. Specimens selected for analysis should include those for which other data (physical properties tests, slaking tests, and/or petrographic analyses) are already available.

Samples for chemical analysis were taken from the pieces of core that remained after specimens had been removed for physical properties tests, slaking tests, and petrographic analysis. These pieces of core ranged from 6 to 24 in. in length. The soft cores of clay and shale were sliced into disks with a knife. The outside edges of the disks were then pared off to remove contamination introduced by the coring operation. All cores of hard rocks, except portions taken for water analysis, were sliced into disks with a diamond wheel. The outside edges of these disks were chipped off with a hammer and chisel to remove contamination from the coring operation.

Samples for water analysis were broken off the core with a hammer and chisel immediately after the core was unwrapped. These samples were promptly crushed in a chipmunk crusher and sealed in plastic bags. Each bagged sample was stored in a sealed paint can until it was analyzed for water.

Two portions of each sample were pulverized for elemental analysis. One portion, pulverized in a chrome-steel unit, was used to obtain the tungsten and cobalt analyses. The second portion, pulverized in a tungsten carbide unit, was used to obtain the iron and chromium analyses.

The procedure for preparing the samples was designed to minimize sample contamination, but some sources of contamination remain. Contamination from minerals in the water used to cool the cutoff saw is difficult to determine but probably negligible, because the cores were generally nonporous. Traces of Fe, Ni, Cr, Cu, Zn, Pb, and Sn could have been introduced from the cutoff saw. The iron contamination from this source is probably negligible compared with the Fe content of the samples, but the Ni, Cr, Cu, Zn, Pb, and Sn results will be biased high.

[2] P. R. Fisher, U. S. Army Corps of Engineers Nuclear Cratering Group, Livermore, Calif., private communication (1968).

Analysis

All samples were dried at 110°C for all analyses except the free- and bound-water analyses.

The free-water content of six samples was determined by heating the samples to 110°C in a vacuum. The water was collected and weighed. The accuracy of this method is about ±5 percent of the free-water content of the sample. However, the free-water content of rock samples is very dependent on sample history. Free water may be either gained or lost in coring and subsequent handling operations. Of the four methods used to protect the cores from water loss, the method of wrapping in aluminum foil and dipping in paraffin is the only one adequate to prevent loss of free water during long-term (1-6 months) storage. All of the aluminum-foil-wrapped cores in this group of 39 samples had been opened prior to sampling for chemical analysis. Therefore, the six analyses for free water were run on samples preserved by one of the other three methods. Results for these six samples are probably low.

The bound-water results show the amount of water evolved by the samples when they were heated between 110 and 1000°C in a vacuum. The water was collected and weighed. In the absence of hydrocarbons, the accuracy of this method is about ±5 percent of the bound-water content of the sample. At temperatures approaching 1000°C, hydrocarbons in the rock samples can react with metallic oxides to form water. This reaction probably occurred on the 781-ft sample from Hole No. 17-CH-13, because oil was collected in the water trap during the analysis. When this reaction occurs, the bound water results are biased high. The bound-water content of rock samples is not very dependent on sample history, although overheating during the coring operation can cause a loss of bound water. Except for the sample mentioned above, the bound-water results probably represent the actual bound-water content of the in situ rock.

To determine the ratio of Fe(II) to Fe(III), samples were leached in a solution of HCl and HF under an inert atmosphere. The Fe(II) and Fe(III) contents of the solution were determined by titration. The accuracy of the titration is about ±1 percent of the Fe(II)-Fe(III) ratio in the solution. For samples which dissolve completely and are free of interfering elements, this method gives results which approximate the Fe(II)-Fe(III) ratio of the in situ rock. However, rock samples seldom dissolve completely in the HCl-HF leach solution and almost always contain some interfering elements.

During the determination of total iron, it became evident that the iron in many of these samples was not leached out of the rock completely by the HCl-HF leach solution. The total iron was determined on separate samples that were completely dissolved in a solution of HNO_3, $HClO_4$, and HF. Table I compares the total iron content of these samples with that of the HCl-HF leach solutions. These data indicate that the iron was not always completely leached out of the rock by the HCl-HF leach solution.

Table I. Comparison of total-iron-analysis results for samples leached in HCl-HF solution and samples completely dissolved in HNO_3-$HClO_4$-HF solution.

Sample No.	Depth, ft	Total Fe, % Leached	Total Fe, % Dissolved	Sample No.	Depth, ft	Total Fe, % Leached	Total Fe, % Dissolved
17-CH-4[a]	113	2.54	4.59	17-CH-12	179.8-182.3	6.52	6.71
17-CH-4[a]	385	3.30	4.68	17-CH-12	288.2-289.0	5.80	6.13
17-CH-5[a]	195.2-196.8	1.33	1.36	17-CH-12	385.6-387.1	6.97	7.18
17-CH-5	284.0-284.7	1.46	1.45	17-CH-12	970	5.15	5.37
17-CH-5	400	1.85	1.83	17-CH-13[a]	321	4.70	5.56
17-CH-6A	650	3.52	3.46	17-CH-13[a]	781	4.58	5.48
17-CH-7	104.3-106.8	7.12	7.22	17-CH-14	496.2-497.4 and 500.5-501.2	5.92	6.02
17-CH-7	647.6-648.6	6.86	6.88				
17-CH-7[a]	672	1.29	2.25				
17-CH-8[a]	260.8-262.7	3.01	3.50	17-CH-14	576.5-578.2	4.89	5.06
17-CH-9[a]	352	4.08	5.40	17-CH-14	601.4-603.9	5.16	5.35
17-CH-9[a]	460-462	1.26	2.13	17-CH-14	715	4.98	5.19
17-CH-9	648-658	2.32	2.73	17-CH-15[a]	272.5-274.0, 275.2-275.9, and 278.9-279.2	4.23	4.83
17-CH-9[a]	873	3.56	4.35				
17-CH-10[a]	363.7-364.2 and 365.3-366.5	0.53	0.57	17-CH-15[a]	416.8-417.8 and 418.9-420.2	4.61	4.92
17-CH-10[a]	495	1.40	2.14				
17-CH-11	86.1-89.0	5.60	5.78				
17-CH-11	496.5-499.0	6.12	6.24	17-CH-17[a]	113	4.84	5.72
17-CH-11	801.8-803.2	6.98	7.05	17-CH-18[a]	208.2-209.8	2.39	2.52
17-CH-11	925.8-928.7	6.20	6.21	17-CH-21	150.5-154.5	5.27	5.37
17-CH-12	118.4-119.1 and 120.2-120.8	5.11	5.42	17-CH-22	500	7.33	7.37
				17-CH-22	1443	6.10	6.49

[a]Contains more than 0.1 percent sulfur.

Many of these samples contained more than 0.1 percent sulfur. Part of this sulfur is probably present as sulfide, which reduces Fe(III) to Fe(II) during the leaching process. This causes results for the Fe(II)-Fe(III) ratio to be biased high.

The analytical results for core samples with less than 0.1 percent sulfur and good agreement between the two analyses for total iron are probably within 5 percent of the actual Fe(II)-Fe(III) ratio in the samples. Results for samples with more than 0.1 percent sulfur or poor agreement between the two total-iron analyses probably do not represent the actual Fe(II)-Fe(III) ratios of their respective cores.

Methods used to obtain the remaining analyses include wet chemistry, atomic

absorption spectroscopy, emission spectrography, and spark-source mass spectrography. Results are shown in Appendix A.

The samples that were analyzed represent only the 6-24 in. of the core from which they were taken. Their relation to the in situ rock formation depends primarily on the homogeneity of the rock mass, which can be estimated by comparing the major element analyses obtained by the Corps of Engineers (Appendix B) with the corresponding analyses obtained by LRL.

On some samples, the Corps of Engineers analyzed alternate slices of the same core used by LRL. For these samples, the Corps of Engineers lab and LRL sample numbers, the core hole and boring numbers, and the depth of sample correspond. On other samples, the Corps of Engineers used a different section of core than LRL. For these samples, the various numbers and depths are different.

A comparison of the results shown in Table II illustrates the differences in composition that may be expected of samples from rock formations that vary from homogeneous to heterogeneous. The analyses shown for Core Hole 17-CH-13 at a depth of 321 ft typify a homogeneous core sample. The analyses shown for Core Hole 17-CH-13 at a depth of 321 ft typify a homogenous core sample. The analyses shown for Core Hole 17-CH-5 at a depth of 400 ft indicate that the core sample is heterogeneous. The heterogeneity in this sample could be caused by pebbles of one rock type included in a matrix of a different type, by lamination of two or more rock types, or by a transition from one type of rock to another within the length of the core.

The two samples taken from Core Hole 17-CH-13 at 781 and 789 ft represent a formation that has a fairly uniform composition throughout this interval of depth. For Core Hole 17-CH-10, the sample taken at 500 ft is a distinctly different type of rock than the sample taken at 495 ft. Some knowledge of the geology associated with the core hole is required to determine whether one of these samples represents a matrix and the other represents an included boulder or whether the two samples were taken from different rock formations.

Water analyses for two sets of samples are also given in Table II. The hygroscopic water reported by the Corps of Engineers represents the weight lost by the sample when it was dried in an oven at 105°C. The water of crystallization they report is the water evolved by the sample between 105 and 850°C. The sample was heated in a tube furnace. The water of crystallization was collected on magnesium perchlorate and weighed. For the 400-ft sample from Core Hole 17-CH-5, the difference between the Corps of Engineers hygroscopic water and the LRL free water, as well as the difference between the Corps of Engineers water of crystallization and the LRL bound water, is due to the different analytical techniques. The total water content reported by the two laboratories agrees within the limits of analytical error.

The difference between the Corps of Engineers water of crystallization and the LRL bound water on the 789-ft and 781-ft samples from Core Hole 17-CH-13 is probably due to the difference in analytical

Table II. Comparison of results obtained by the Corps of Engineers and Lawrence Radiation Laboratory. All results are in percent.

Sampling procedure:	Alternate slices of same core sample				Different core samples			
Core hole:	17-CH-13		17-CH-5		17-CH-13		17-CH-10	
Depth, ft:	321		400		789	781	500	495
Laboratory:	C of E[a]	LRL	C of E[a]	LRL	C of E[a]	LRL	C of E[a]	LRL
SiO_2	47.30	48.37	54.23	49.44	50.71	46.74	71.94	48.56
Al_2O_3	16.14	16.52	14.16	7.28	17.51	16.52	3.10	7.80
Fe_2O_3	7.79	7.95	5.69	2.62	8.48	7.84	1.23	3.06
MnO	0.05	0.06	0.06	0.05	0.95	1.03	0.08	0.10
TiO_2	0.73	1.25	0.39	0.43	0.05	1.28	0.08	0.30
P_2O_5	1.60	1.37	0.23	0.09	0.25	0.18	0.06	0.06
CaO	6.46	6.32	9.72	18.66	4.77	7.36	10.77	19.22
MgO	3.93	3.00	2.44	1.16	3.40	3.25	0.83	1.69
Na_2O	1.60	1.75	1.54	1.27	1.40	1.89	0.42	1.48
K_2O	1.55	1.69	0.76	0.90	0.97	1.45	0.28	0.98
CO_2	5.69	5.90	5.08	12.20	3.60	4.99	9.39	13.30
Total	92.84	94.18	94.30	93.92	92.09	92.53	98.18	96.55
Hygroscopic H_2O			1.53		4.78			
Free H_2O				4.02		16.96		
H_2O of Crystallization			6.18		6.88			
Bound H_2O				3.62		4.84		
Total H_2O			7.71	7.62	11.66	21.80		

[a]Corps of Engineers' results for oxides are corrected to an oven-dried (105°C) basis.

techniques. However, the difference between the Corps of Engineers hygroscopic water and the LRL free water, together with the difference in total water found by the two laboratories, indicates that the two samples actually had different water contents. Because the samples were taken 8 ft apart, it is possible that the actual water content of the in situ rock differed by a factor of 1.87. However, it is more probable that the difference in the total water content of the two samples is the difference in the amount of water lost by the two samples due to poor packaging techniques.

Acknowledgments

The analyses presented in this report represent the cooperative efforts of many people. Dr. Clifford Chunn, U.S. Army Engineering Division Laboratory, South Atlantic Corps of Engineers, Marietta, Georgia, provided the facilities and personnel for sampling the cores. P. R. Fisher, U.S. Army Engineers Nuclear Cratering Group, Livermore, and D. R. Stephens, Lawrence Radiation Laboratory, Livermore, obtained missing core samples in Panama. The samples were analyzed by W. G. Boyle, L. J. Gregory, R. Lim, C. G. Morris, William F. Morris, R. L. Morrison, William E. Sunderland, and E. G. Walters, Lawrence Radiation Laboratory, Livermore. The manuscript was critically read by E. H. Fleming, J. W. Frazer, and J. E. Harrar. The author wishes to acknowledge the efforts of the people mentioned above and also to express his appreciation to others who also contributed but are not mentioned.

Appendix A

ELEMENTAL ANALYSIS OF CORE SAMPLES BY LAWRENCE RADIATION LABORATORY

These data were obtained by wet chemistry, atomic absorption spectroscopy, emission spectrography, and spark-source mass spectrography. For the analyses by the first three methods, the approximate accuracy is given as a percentage of the concentration of the element in the sample. Where the accuracy is not indicated, the results were obtained by spark-source mass spectrography. A comparison of results indicates that spark-source mass-spectrographic results generally agree within a factor of 2 with the results obtained by more accurate methods. Spark-source mass-spectrographic results that disagree with more accurate results by more than a factor of 2 are usually biased high.

Elements for which no results are given are present in concentrations of less than 1 ppm.

ANALYTICAL REPORT

Material: Calcareous shale with silty interbeds

17-CH-4 113'

LRL Sample No. 222/183

Z		Weight %	±	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na	± **		±	50.	Sn		±	0.1	±
2.	He	na	±		±	51.	Sb		±	0.05	±
3.	Li		±	90	±5%	52.	Te		±		±
4.	Be	na	±		±	53.	I		±		±
5.	B		±	70	±50%	55.	Cs		±	0.8	±
6.	C	na	±		±	56.	Ba		±	480	±
7.	N	na	±		±	57.	La		±	8	±
8.	O	na	±		±	58.	Ce		±	13	±
9.	F	na	±		±	59.	Pr		±	2	±
11.	Na	1.0	±5%		±	60.	Nd		±	6	±
12.	Mg	1.04	±2%		±	61.	Pm		±		±
13.	Al	8.9	±2%		±	62.	Sm		±	2	±
14.	Si	24.57	±2%		±	63.	Eu		±	0.4	±
15.	P	0.008	±10%		±	64.	Gd		±	2	±
16.	S	3.40	±5%		±	65.	Tb		±	0.3	±
17.	Cl	na	±		±	66.	Dy		±	2	±
19.	K	0.81	±5%		±	67.	Ho		±		±
20.	Ca	3.02	±2%		±	68.	Er		±	1	±
21.	Sc	na	±		±	69.	Tm	na	±		±
22.	Ti	0.63	±5%		±	70.	Yb		±	1	±
23.	V		±	250	±	71.	Lu		±		±
24.	Cr		±	50	±50	72.	Hf		±		±
25.	Mn	0.04	±20%		±	73.	Ta	na	±		±
26.	Fe	4.59	± 5%		±	74.	W		±		±
27.	Co		±	6	±	75.	Re	na	±		±
28.	Ni		±	105	±	76.	Os		±	0.3	±
29.	Cu		±	120	±	77.	Ir		±		±
30.	Zn		±	50	±	78.	Pt		±		±
31.	Ga	na	±		±	79.	Au		±		±
32.	Ge	na	±		±	80.	Hg		±		±
33.	As		±	2	±	81.	Tl		±		±
34.	Se		±	0.3	±	82.	Pb		±	4	±
35.	Br		±	2	±	83.	Bi		±		±
37.	Rb		±	8	±	84.	Po		±		±
38.	Sr		±	400	±	85.	At		±		±
39.	Y		±	20	±	86.	Rn		±		±
40.	Zr		±	55	±	87.	Fr		±		±
41.	Nb		±	2	±	88.	Ra		±		±
42.	Mo		±	9	±	89.	Ac		±		±
43.	Tc		±		±	90.	Th		±		±
44.	Ru		±	0.1	±	91.	Pa		±		±
45.	Rh	na	±		±	92.	U		±	1	±
46.	Pd		±		±	93.	Np		±		±
47.	Ag		±	0.1	±	94.	Pu		±		±
48.	Cd		±		±	95.	Am		±		±
49.	In		±	0.05	±	96.	Cm		±		±
*CO_2		2.63	±5%		±				±		±
Fe^{+2}/Fe^{+3}		0.75	±5%		±				±		±

Method of Analysis:

*CO_2 from carbonate

**Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

RL-3635

ANALYTICAL REPORT

Material Calcareous shale
17-CH-4 385'

LRL Sample No. 111

Z		Weight %	±	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na	± **		±	50.	Sn		±	0.05	±
2.	He	na	±		±	51.	Sb		±	0.1	±
3.	Li		±	71	±	52.	Te		±		±
4.	Be	na	±		±	53.	I		±	2	±
5.	B		±	80	±	55.	Cs		±	2	±
6.	C	na	±		±	56.	Ba		±	1450.	±
7.	N	na	±		±	57.	La		±	14	±
8.	O	na	±		±	58.	Ce		±	16	±
9.	F	na	±		±	59.	Pr		±	5	±
11.	Na	1.6	± 5%		±	60.	Nd		±	2.	±
12.	Mg	1.82	± 2%		±	61.	Pm		±		±
13.	Al	8.90	± 2%		±	62.	Sm		±	7	±
14.	Si	25.14	± 2%		±	63.	Eu		±	1	±
15.	P	0.049	± 5%		±	64.	Gd		±	5	±
16.	S	2.45	± 5%		±	65.	Tb		±	0.9	±
17.	Cl	na	±		±	66.	Dy		±	4	±
19.	K	0.97	± 5%		±	67.	Ho		±	0.4	±
20.	Ca	3.54	± 2%		±	68.	Er		±	2.5	±
21.	Sc	na	±		±	69.	Tm	na	±		±
22.	Ti	0.55	± 5%		±	70.	Yb		±	2.4	±
23.	V		±	450	±	71.	Lu		±	0.4	±
24.	Cr		±	60	±	72.	Hf		±	2	±
25.	Mn	0.06	± 5%		±	73.	Ta	na	±		±
26.	Fe	4.68	± 5%		±	74.	W		±	1.5	±
27.	Co		±	38	±	75.	Re	na	±		±
28.	Ni		±	210	±	76.	Os		±		±
29.	Cu		±	115	±	77.	Ir		±		±
30.	Zn		±	110	±	78.	Pt		±		±
31.	Ga	na	±		±	79.	Au		±		±
32.	Ge	na	±		±	80.	Hg		±		±
33.	As		±	4	±	81.	Tl		±	0.4	±
34.	Se		±	18	±	82.	Pb		±	2	±
35.	Br		±	6	±	83.	Bi		±		±
37.	Rb		±	14	±	84.	Po		±		±
38.	Sr		±	760	±	85.	At		±		±
39.	Y		±	24	±	86.	Rn		±		±
40.	Zr		±	75	±	87.	Fr		±		±
41.	Nb		±	4	±	88.	Ra		±		±
42.	Mo		±	44	±	89.	Ac		±		±
43.	Tc		±		±	90.	Th		±	1	±
44.	Ru		±	0.05	±	91.	Pa		±		±
45.	Rh	na	±		±	92.	U		±	3	±
46.	Pd		±	0.2	±	93.	Np		±		±
47.	Ag		±	0.1	±	94.	Pu		±		±
48.	Cd		±	0.7	±	95.	Am		±		±
49.	In		±	< 0.05	±	96.	Cm		±		±
*CO_2		3.69	± 5%		±				±		±
Fe^{-2}/Fe^{+3}		0.87	± 5%		±				±		±

Method of Analysis:
*CO_2 from carbonate
**Expressed as a percent of the concentration.
na - not analyzed

Analytical Lab.
Lab. Sample No.
Date:
Signed:

ANALYTICAL REPORT

Material: Slightly weathered silty and tuffaceous limestone

LRL Sample No. 1 M 1200

17-CH-5 195.2-196.8'

Z		Weight %	±	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na	**			50.	Sn				
2.	He	na				51.	Sb			< 0.05	
3.	Li			11	±10%	52.	Te				
4.	Be	na				53.	I			0.2	
5.	B			5		55.	Cs			0.05	
6.	C	na				56.	Ba			2050	
7.	N	na				57.	La			3	
8.	O	na				58.	Ce			3	
9.	F	na				59.	Pr			.8	
11.	Na	0.90	± 5%			60.	Nd			3	
12.	Mg	0.58	± 2%			61.	Pm				
13.	Al	3.47	± 2%			62.	Sm			2	
14.	Si	27.42	± 2%			63.	Eu			0.5	
15.	P	0.006	± 20%			64.	Gd			1	
16.	S	0.101	± 5%			65.	Tb			0.4	
17.	Cl	na				66.	Dy			0.9	
19.	K	0.64	± 5%			67.	Ho			0.2	
20.	Ca	10.66	± 2%			68.	Er				
21.	Sc	na				69.	Tm	na			
22.	Ti	0.16	± 5%			70.	Yb			0.8	
23.	V			40		71.	Lu				
24.	Cr			10	±50%	72.	Hf				
25.	Mn	0.04	± 20%			73.	Ta	na			
26.	Fe	1.33	± 5%			74.	W			2	
27.	Co			13		75.	Re	na			
28.	Ni			1		76.	Os				
29.	Cu			65		77.	Ir				
30.	Zn			1		78.	Pt				
31.	Ga	na				79.	Au				
32.	Ge	na				80.	Hg				
33.	As			0.05		81.	Tl				
34.	Se			0.3		82.	Pb			0.8	
35.	Br			0.5		83.	Bi				
37.	Rb			1		84.	Po				
38.	Sr			225		85.	At				
39.	Y			4		86.	Rn				
40.	Zr			11		87.	Fr				
41.	Nb			0.2		88.	Ra				
42.	Mo					89.	Ac				
43.	Tc					90.	Th			< 0.05	
44.	Ru			< 0.05		91.	Pa				
45.	Rh	na				92.	U				
46.	Pd			< 0.05		93.	Np				
47.	Ag			< 0.05		94.	Pu				
48.	Cd					95.	Am				
49.	In					96.	Cm				
	*CO_2	9.89	± 5%								
	Fe^{+2}/Fe^{2+3}	0.35	± 5%								

Method of Analysis:

*CO_2 from carbonate

** Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

RL-3635

ANALYTICAL REPORT

Material Altered tuff — LRL Sample No. 115

17-CH-5 262-263'

Z		Weight %	± **	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na				50.	Sn			< 0.05	
2.	He	na				51.	Sb			0.05	
3.	Li			10	± 10%	52.	Te				
4.	Be	na				53.	I			0.9	
5.	B			15	± 50%	55.	Cs			0.2	
6.	C	na				56.	Ba			3200	
7.	N	na				57.	La			8	
8.	O	na				58.	Ce			5	
9.	F	na				59.	Pr			2	
11.	Na	0.74	± 5%			60.	Nd			6	
12.	Mg	0.42	± 2%			61.	Pm				
13.	Al	2.72	± 2%			62.	Sm			4	
14.	Si	29.69	± 2%			63.	Eu			1	
15.	P	0.025	± 5%			64.	Gd			1	
16.	S	0.074	± 5%			65.	Tb			0.5	
17.	Cl	na				66.	Dy			1	
19.	K	0.67	± 5%			67.	Ho			0.3	
20.	Ca	9.93	± 2%			68.	Er			0.7	
21.	Sc	na				69.	Tm	na			
22.	Ti	0.11	± 5%			70.	Yb			0.8	
23.	V			80		71.	Lu				
24.	Cr			15	± 50%	72.	Hf			< 0.05	
25.	Mn	0.02	± 20%			73.	Ta	na			
26.	Fe	0.95	± 5%			74.	W			1.5	
27.	Co			7		75.	Re	na			
28.	Ni			4		76.	Os				
29.	Cu			24		77.	Ir				
30.	Zn			41		78.	Pt				
31.	Ga	na				79.	Au				
32.	Ge	na				80.	Hg				
33.	As			0.05		81.	Tl				
34.	Se			0.3		82.	Pb			0.6	
35.	Br			0.3		83.	Bi				
37.	Rb			2		84.	Po				
38.	Sr			330		85.	At				
39.	Y			0.8		86.	Rn				
40.	Zr			14		87.	Fr				
41.	Nb			0.2		88.	Ra				
42.	Mo			0.05		89.	Ac				
43.	Tc					90.	Th				
44.	Ru			2		91.	Pa				
45.	Rh	na				92.	U				
46.	Pd			0.05		93.	Np				
47.	Ag			0.05		94.	Pu				
48.	Cd					95.	Am				
49.	In			< 0.05		96.	Cm				
*CO_2		9.45	± 5%								
Fe^{+2}/Fe^{2+3}		0.46	± 5%								

Method of Analysis:
*CO_2 from carbonate
**Expressed as a percent of the concentration
na - not analyzed

Analytical Lab. _____
Lab. Sample No. _____
Date: _____
Signed: _____

RL-3635

ANALYTICAL REPORT

Material Fresh Calcareous Tuff
17-CH-5 284.0-284.7'

LRL Sample No. 1M 1006

Z	Weight %	±	Weight PPM	±	Z	Weight %	±	Weight PPM	±
1. H	na	±**		±	50. Sn		±		±
2. He	na	±		±	51. Sb		±		±
3. Li		±	11	±10%	52. Te		±		±
4. Be	na	±		±	53. I		±	0.3	±
5. B		±	10	±50%	55. Cs		±	0.2	±
6. C	na	±		±	56. Ba		±	280	±
7. N	na	±		±	57. La		±	8	±
8. O	na	±		±	58. Ce		±	9	±
9. F	na	±		±	59. Pr		±	2.5	±
11. Na	1.2	± 5%		±	60. Nd		±	10	±
12. Mg	0.66	± 2%		±	61. Pm		±		±
13. Al	4.23	± 2%		±	62. Sm		±	5	±
14. Si	29.14 q	± 2%		±	63. Eu		±	2	±
15. P	0.017	± 5%		±	64. Gd		±	3	±
16. S	0.033	± 5%		±	65. Tb		±	0.9	±
17. Cl	na	±		±	66. Dy		±	2.5	±
19. K	0.99	± 5%		±	67. Ho		±	0.5	±
20. Ca	6.99	± 2%		±	68. Er		±	2	±
21. Sc	na	±		±	69. Tm	na	±		±
22. Ti	0.25	± 5%		±	70. Yb		±	2	±
23. V		±	40	±	71. Lu		±	0.3	±
24. Cr		±	10	±50%	72. Hf		±	1.5	±
25. Mn	0.02	±20%		±	73. Ta	na	±		±
26. Fe	1.46	± 5%		±	74. W		±	3	±
27. Co		±	12	±	75. Re	na	±		±
28. Ni		±	9	±	76. Os		±		±
29. Cu		±	8	±	77. Ir		±		±
30. Zn		±	17	±	78. Pt		±		±
31. Ga	na	±		±	79. Au		±		±
32. Ge	na	±		±	80. Hg		±		±
33. As		±	0.2	±	81. Tl		±		±
34. Se		±	0.3	±	82. Pb		±	2	±
35. Br		±	0.5	±	83. Bi		±		±
37. Rb		±	3	±	84. Po		±		±
38. Sr		±	230	±	85. At		±		±
39. Y		±	30	±	86. Rn		±		±
40. Zr		±	25	±	87. Fr		±		±
41. Nb		±	0.5	±	88. Ra		±		±
42. Mo		±		±	89. Ac		±		±
43. Tc		±		±	90. Th		±	0.5	±
44. Ru		±	10	±	91. Pa		±		±
45. Rh	na	±		±	92. U		±		±
46. Pd		±		±	93. Np		±		±
47. Ag		±		±	94. Pu		±		±
48. Cd		±		±	95. Am		±		±
49. In		±		±	96. Cm		±		±
*CO_2	5.55	± 5%		±			±		±
Fe^{+2}/Fe^{+3}	0.38	± 5%		±			±		±

Method of Analysis:
*CO_2 from carbonate
** Expressed as a percent of the concentration
na - not analyzed

Analytical Lab. _____
Lab. Sample No. _____
Date: _____
Signed: _____

RL-3635

ANALYTICAL REPORT

Material Bedded tuff — LRL Sample No. 113

17-CH-5 400'

Z		Weight %	±	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na	**			50.	Sn			0.05	
2.	He	na				51.	Sb			< 0.05	
3.	Li			9	± 10%	52.	Te				
4.	Be	na				53.	I			0.5	
5.	B			5		55.	Cs			0.3	
6.	C	na				56.	Ba			3400	
7.	N	na				57.	La			18	
8.	O	na				58.	Ce			11	
9.	F	na				59.	Pr			3	
11.	Na	0.94	± 5%			60.	Nd			12	
12.	Mg	0.70	± 2%			61.	Pm				
13.	Al	3.85	± 2%			62.	Sm			5	
14.	Si	23.10	± 2%			63.	Eu			1	
15.	P	0.040	± 5%			64.	Gd			3	
16.	S	0.022	± 5%			65.	Tb			0.8	
17.	Cl	na				66.	Dy			3	
19.	K	0.75	± 5%			67.	Ho			0.5	
20.	Ca	13.34	± 2%			68.	Er			1.5	
21.	Sc	na				69.	Tm	na			
22.	Ti	0.26	± 5%			70.	Yb			2	
23.	V			85		71.	Lu			0.3	
24.	Cr			10	± 50%	72.	Hf			2	
25.	Mn	0.04	± 20%			73.	Ta	na			
26.	Fe	1.85	± 5%			74.	W			6	
27.	Co			28		75.	Re	na			
28.	Ni			6		76.	Os				
29.	Cu			40		77.	Ir				
30.	Zn			60		78.	Pt				
31.	Ga	na				79.	Au				
32.	Ge	na				80.	Hg				
33.	As			0.3		81.	Tl				
34.	Se			0.5		82.	Pb			2	
35.	Br			0.5		83.	Bi				
37.	Rb			4		84.	Po				
38.	Sr			415		85.	At				
39.	Y			30		86.	Rn				
40.	Zr			45		87.	Fr				
41.	Nb			0.8		88.	Ra				
42.	Mo					89.	Ac				
43.	Tc					90.	Th			0.5	
44.	Ru			4		91.	Pa				
45.	Rh	na				92.	U			0.5	
46.	Pd			< 0.05		93.	Np				
47.	Ag			0.1		94.	Pu				
48.	Cd					95.	Am				
49.	In			0.05		96.	Cm				
	$*CO_2$	12.2	± 5%				Free H_2O	4.02	± 5%		
	Fe^{+2}/Fe^{+3}	0.35	± 5%				Bound H_2O	3.62	± 5%		

Method of Analysis:

$*CO_2$ from carbonate

** Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

RL-3635

ANALYTICAL REPORT

Material Porphyritic basalt — LRL Sample No. 125

17-CH-6A 650'

Z		Weight %	±	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na	**			50.	Sn			0.05	
2.	He	na				51.	Sb			< 0.05	
3.	Li			5	± 20%	52.	Te				
4.	Be			0.5		53.	I				
5.	B			< 5		55.	Cs			0.8	
6.	C	na				56.	Ba			450	± 50%
7.	N	na				57.	La			8	± 50%
8.	O	na				58.	Ce			20	
9.	F	na				59.	Pr			5	
11.	Na	2.5	± 5%			60.	Nd			15	
12.	Mg	0.93	± 2%			61.	Pm				
13.	Al	7.04	± 2%			62.	Sm			6	
14.	Si	29.56	± 2%			63.	Eu			0.9	
15.	P	0.082	± 5%			64.	Gd			4	
16.	S	0.022	± 5%			65.	Tb			0.7	
17.	Cl	na				66.	Dy			4	
19.	K	0.47	± 5%			67.	Ho			0.7	
20.	Ca	2.57	± 2%			68.	Er			2.5	
21.	Sc			15	± 50%	69.	Tm	na			
22.	Ti	0.68	± 5%	4250		70.	Yb			2	
23.	V			20	± 50%	71.	Lu			< 0.05	
24.	Cr			< 1		72.	Hf			3	
25.	Mn	0.06	± 20%			73.	Ta	na			
26.	Fe	3.52	± 5%			74.	W				
27.	Co			8		75.	Re	na			
28.	Ni			< 1		76.	Os				
29.	Cu			50	± 50%	77.	Ir				
30.	Zn			40	± 50%	78.	Pt				
31.	Ga			< 10	± 50%	79.	Au				
32.	Ge	na				80.	Hg				
33.	As			0.05		81.	Tl				
34.	Se			0.4		82.	Pb			0.7	
35.	Br			0.8		83.	Bi				
37.	Rb			1.4		84.	Po				
38.	Sr			250	± 50%	85.	At				
39.	Y			20	± 50%	86.	Rn				
40.	Zr			200	± 50%	87.	Fr				
41.	Nb			2		88.	Ra				
42.	Mo			< 0.05		89.	Ac				
43.	Tc					90.	Th			0.5	
44.	Ru			< 0.05		91.	Pa				
45.	Rh	na				92.	U				
46.	Pd			0.2		93.	Np				
47.	Ag			0.1		94.	Pu				
48.	Cd					95.	Am				
49.	In			< 0.05		96.	Cm				
* CO_2		0.07	± 10%								
Fe^{+2}/Fe^{2+3}		0.26	± 5%								

Method of Analysis:

* CO_2 from carbonate

** Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

RL-3635

ANALYTICAL REPORT

Material: Slightly weathered and altered diabase

17-CH-7 104.3-106.8'

LRL Sample No. 1 M 1089

Z		Weight %	± **	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na				50.	Sn			0.1	
2.	He	na				51.	Sb				
3.	Li			4	± 20%	52.	Te			1	
4.	Be			< 0.5		53.	I				
5.	B			< 5		55.	Cs			0.3	
6.	C	na				56.	Ba			70.	± 50%
7.	N	na				57.	La			0.9	
8.	O	na				58.	Ce			3	
9.	F	na				59.	Pr			0.3	
11.	Na	1.8	± 5%			60.	Nd			3	
12.	Mg	4.95	± 2%			61.	Pm				
13.	Al	8.00	± 2%			62.	Sm			3	
14.	Si	22.17	± 2%			63.	Eu			0.4	
15.	P	0.0004	± 50%			64.	Gd			3	
16.	S	0.027	± 5%			65.	Tb			0.5	
17.	Cl	na				66.	Dy			1	
19.	K	0.056	± 5%			67.	Ho			0.3	
20.	Ca	9.28	± 2%			68.	Er			0.3	
21.	Sc			25	± 50%	69.	Tm	na			
22.	Ti	0.90	± 5%			70.	Yb			1.7	
23.	V			200	± 50%	71.	Lu				
24.	Cr			200	± 50%	72.	Hf				
25.	Mn	0.09	± 10%			73.	Ta	na			
26.	Fe	7.12	± 5%			74.	W				
27.	Co					75.	Re	na			
28.	Ni			70	± 50%	76.	Os				
29.	Cu			120	± 50%	77.	Ir				
30.	Zn			40	± 50%	78.	Pt				
31.	Ga			20	± 50%	79.	Au				
32.	Ge	na				80.	Hg				
33.	As			1		81.	Tl				
34.	Se			2		82.	Pb			0.6	
35.	Br			1		83.	Bi				
37.	Rb			1		84.	Po				
38.	Sr			75	± 50%	85.	At				
39.	Y			10	± 50%	86.	Rn				
40.	Zr			75	± 50%	87.	Fr				
41.	Nb			1		88.	Ra				
42.	Mo			0.7		89.	Ac				
43.	Tc					90.	Th				
44.	Ru					91.	Pa				
45.	Rh	na				92.	U				
46.	Pd					93.	Np				
47.	Ag					94.	Pu				
48.	Cd					95.	Am				
49.	In			3		96.	Cm				
*CO_2		0.09	± 10%								
Fe^{+2}/Fe^{+3}		1.89	± 5%								

Method of Analysis:

*CO_2 from carbonate

** Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

RL-3635

ANALYTICAL REPORT

Material: Slightly weathered altered diabase
17-CH-7 647.6 - 648.6'

LRL Sample No. 1M 1093

Z		Weight %	±	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na	**			50.	Sn			0.2	
2.	He	na				51.	Sb				
3.	Li			6	±20%	52.	Te				
4.	Be	na				53.	I				
5.	B			20	±50%	55.	Cs				
6.	C	na				56.	Ba			1600	
7.	N	na				57.	La			3	
8.	O	na				58.	Ce			5	
9.	F	na				59.	Pr			0.8	
11.	Na	1.6	± 5%			60.	Nd			3	
12.	Mg	4.81	± 2%			61.	Pm				
13.	Al	7.74	± 2%			62.	Sm			5	
14.	Si	21.59	± 2%			63.	Eu			0.8	
15.	P	0.006	±20%			64.	Gd			3	
16.	S	0.056	± 5%			65.	Tb			1	
17.	Cl	na				66.	Dy			6	
19.	K	0.20	± 5%			67.	Ho			1	
20.	Ca	10.03	± 2%			68.	Er			5	
21.	Sc	na				69.	Tm	na			
22.	Ti	0.86	± 5%			70.	Yb			5	
23.	V			250		71.	Lu				
24.	Cr			200	±50%	72.	Hf			2	
25.	Mn	0.08	±10%			73.	Ta	na			
26.	Fe	6.86	± 5%			74.	W			7	
27.	Co			25		75.	Re	na			
28.	Ni			75		76.	Os				
29.	Cu			150		77.	Ir				
30.	Zn			250		78.	Pt				
31.	Ga	na				79.	Au				
32.	Ge	na				80.	Hg				
33.	As			0.2		81.	Tl				
34.	Se			1		82.	Pb			1	
35.	Br			2		83.	Bi				
37.	Rb			1		84.	Po				
38.	Sr			100		85.	At				
39.	Y			35		86.	Rn				
40.	Zr			25		87.	Fr				
41.	Nb			0.6		88.	Ra				
42.	Mo					89.	Ac				
43.	Tc					90.	Th				
44.	Ru			6		91.	Pa				
45.	Rh	na				92.	U				
46.	Pd					93.	Np				
47.	Ag			0.2		94.	Pu				
48.	Cd					95.	Am				
49.	In			0.2		96.	Cm				
*CO_2		0.11	± 5%								
Fe^{+2}/Fe^{+3}		1.38	± 5%								

Method of Analysis:
*CO_2 from carbonate
na - not analyzed
** Expressed as a percent of the concentration

Analytical Lab. _____
Lab. Sample No. _____
Date: _____
Signed: _____

RL-3635

ANALYTICAL REPORT

Material Calcareous tuff — LRL Sample No. 114

17-CH-7 672'

Z	Weight %	± **	Weight PPM	±	Z	Weight %	±	Weight PPM	±
1. H	na				50. Sn			0.1	
2. He	na				51. Sb			0.1	
3. Li			3	±50%	52. Te				
4. Be	na				53. I			0.3	
5. B			< 5		55. Cs				
6. C	na				56. Ba			44	
7. N	na				57. La			7	
8. O	na				58. Ce			2.5	
9. F	na				59. Pr			1	
11. Na	0.44	± 5%			60. Nd			4	
12. Mg	0.70	± 2%			61. Pm				
13. Al	1.72	± 2%			62. Sm			2	
14. Si	21.46	± 2%			63. Eu			0.3	
15. P	0.041	± 5%			64. Gd			1	
16. S	1.45	± 5%			65. Tb			0.2	
17. Cl	na				66. Dy			1.5	
19. K	0.046	± 5%			67. Ho			0.3	
20. Ca	17.50	± 2%			68. Er			1	
21. Sc	na				69. Tm	na			
22. Ti	0.28	± 5%			70. Yb			1	
23. V			115		71. Lu			< 0.05	
24. Cr			75	±50%	72. Hf			< 0.05	
25. Mn	0.03	± 20%			73. Ta	na			
26. Fe	2.25	± 5%			74. W				
27. Co			10		75. Re	na			
28. Ni			31		76. Os				
29. Cu			48		77. Ir				
30. Zn			70		78. Pt				
31. Ga	na				79. Au				
32. Ge	na				80. Hg				
33. As			2		81. Tl			0.1	
34. Se			0.6		82. Pb			1	
35. Br			0.3		83. Bi				
37. Rb			0.05		84. Po				
38. Sr			75		85. At				
39. Y			20		86. Rn				
40. Zr			18		87. Fr				
41. Nb			0.5		88. Ra				
42. Mo			18		89. Ac				
43. Tc					90. Th				
44. Ru			10		91. Pa				
45. Rh	na				92. U			0.5	
46. Pd					93. Np				
47. Ag			2		94. Pu				
48. Cd					95. Am				
49. In			< 0.05		96. Cm				
*CO_2	18.0	± 5%							
Fe^{+2}/Fe^{+3}	2.06	± 5%							

Method of Analysis:

*CO_2 from carbonate

** Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

RL-3635

ANALYTICAL REPORT

Material: Tuffaceous fossiliferous limestone
17-CH-8 260.8-262.7'

LRL Sample No. 1M 1177

Z		Weight %		Weight PPM		Z		Weight %		Weight PPM	
1.	H	na	± **		±	50.	Sn		±	0.05	±
2.	He	na	±		±	51.	Sb		±	0.05	±
3.	Li		±	11	± 10%	52.	Te		±		±
4.	Be	na	±		±	53.	I		±	0.8	±
5.	B		±	5	±	55.	Cs		±	0.5	±
6.	C	na	±		±	56.	Ba		±	640	±
7.	N	na	±		±	57.	La		±	14	±
8.	O	na	±		±	58.	Ce		±	11	±
9.	F	na	±		±	59.	Pr		±	3	±
11.	Na	0.52	± 5%		±	60.	Nd		±	9	±
12.	Mg	1.26	± 2%		±	61.	Pm		±		±
13.	Al	3.07	± 2%		±	62.	Sm		±	4	±
14.	Si	10.73	± 2%		±	63.	Eu		±	0.8	±
15.	P	0.077	± 5%		±	64.	Gd		±	2.5	±
16.	S	1.10	± 5%		±	65.	Tb		±	0.5	±
17.	Cl	na	±		±	66.	Dy		±	3	±
19.	K	0.76	± 5%		±	67.	Ho		±	0.4	±
20.	Ca	24.44	± 2%		±	68.	Er		±	1	±
21.	Sc	na	±		±	69.	Tm	na	±		±
22.	Ti	0.70	± 5%		±	70.	Yb		±	1	±
23.	V		±	115	±	71.	Lu		±	<0.05	±
24.	Cr		±	45	± 50%	72.	Hf		±	2	±
25.	Mn	0.02	± 20%		±	73.	Ta	na	±		±
26.	Fe	3.50	± 5%		±	74.	W		±		±
27.	Co		±	115	±	75.	Re	na	±		±
28.	Ni		±	30	±	76.	Os		±		±
29.	Cu		±	35	±	77.	Ir		±		±
30.	Zn		±	1.5	±	78.	Pt		±		±
31.	Ga	na	±		±	79.	Au		±		±
32.	Ge	na	±		±	80.	Hg		±		±
33.	As		±	0.3	±	81.	Tl		±	<0.05	±
34.	Se		±	0.3	±	82.	Pb		±	2	±
35.	Br		±	0.9	±	83.	Bi		±		±
37.	Rb		±	9	±	84.	Po		±		±
38.	Sr		±	900	±	85.	At		±		±
39.	Y		±	24	±	86.	Rn		±		±
40.	Zr		±	42	±	87.	Fr		±		±
41.	Nb		±	5	±	88.	Ra		±		±
42.	Mo		±	4	±	89.	Ac		±		±
43.	Tc		±		±	90.	Th		±	<0.05	±
44.	Ru		±	7	±	91.	Pa		±		±
45.	Rh	na	±		±	92.	U		±	2	±
46.	Pd		±	<0.05	±	93.	Np		±		±
47.	Ag		±	0.3	±	94.	Pu		±		±
48.	Cd		±	<0.05	±	95.	Am		±		±
49.	In		±	<0.05	±	96.	Cm		±		±
*CO_2		25.2%	± 5%		±				±		±
Fe^{+2}/Fe^{+3}		0.57	± 5%		±				±		±

Method of Analysis:
*CO_2 from carbonate
** Expressed as a percent of the concentration
na - not analyzed

Analytical Lab. _____
Lab. Sample No. _____
Date: _____
Signed: _____

RL-3635

ANALYTICAL REPORT

Material Calcareous Shale
17-CH-9 352'

LRL Sample No. 117

Z	Weight %	±	Weight PPM	±	Z	Weight %	±	Weight PPM	±
1. H	na	±**		±	50. Sn		±		±
2. He	na	±		±	51. Sb		±		±
3. Li		±	67	± 5%	52. Te		±		±
4. Be	na	±		±	53. I		±	0.1	±
5. B		±	200	±50%	55. Cs		±	0.8	±
6. C	na	±		±	56. Ba		±	290	±
7. N	na	±		±	57. La		±	2	±
8. O	na	±		±	58. Ce		±	5	±
9. F	na	±		±	59. Pr		±	0.7	±
11. Na	1.4	± 5%		±	60. Nd		±	2	±
12. Mg	1.53	± 2%		±	61. Pm		±		±
13. Al	9.44	± 2%		±	62. Sm		±	2	±
14. Si	24.37	± 2%		±	63. Eu		±	0.3	±
15. P	0.061	± 5%		±	64. Gd		±	0.6	±
16. S	2.19	± 5%		±	65. Tb		±	0.2	±
17. Cl	na	±		±	66. Dy		±	0.3	±
19. K	1.5	± 5%		±	67. Ho		±		±
20. Ca	3.14	± 2%		±	68. Er		±	0.4	±
21. Sc	na	±		±	69. Tm	na	±		±
22. Ti	0.64	± 5%		±	70. Yb		±		±
23. V		±	110	±	71. Lu		±		±
24. Cr		±	70	±50%	72. Hf		±		±
25. Mn	0.07	±20%		±	73. Ta	na	±		±
26. Fe	5.40	± 5%		±	74. W		±		±
27. Co		±	6	±	75. Re	na	±		±
28. Ni		±	35	±	76. Os		±		±
29. Cu		±	50	±	77. Ir		±		±
30. Zn		±	75	±	78. Pt		±		±
31. Ga	na	±		±	79. Au		±		±
32. Ge	na	±		±	80. Hg		±		±
33. As		±	1	±	81. Tl		±		±
34. Se		±	0.3	±	82. Pb		±	0.8	±
35. Br		±	2	±	83. Bi		±		±
37. Rb		±	4	±	84. Po		±		±
38. Sr		±	165	±	85. At		±		±
39. Y		±	7	±	86. Rn		±		±
40. Zr		±	18	±	87. Fr		±		±
41. Nb		±	0.2	±	88. Ra		±		±
42. Mo		±	1	±	89. Ac		±		±
43. Tc		±		±	90. Th		±		±
44. Ru		±	0.9	±	91. Pa		±		±
45. Rh	na	±		±	92. U		±		±
46. Pd		±		±	93. Np		±		±
47. Ag		±	0.1	±	94. Pu		±		±
48. Cd		±	< 0.05	±	95. Am		±		±
49. In		±	< 0.05	±	96. Cm		±		±
*CO_2	2.63	± 5%		±	Free H_2O	13.05	±5%		±
Fe^{+2}/Fe^{+3}	0.72	± 5%		±	Bound H_2O	5.02	±5%		±

Method of Analysis:
* CO_2 from carbonate
** Expressed as a percent of the concentration
na - not analyzed

Analytical Lab. _____
Lab. Sample No. _____
Date: _____
Signed: _____

RL-3635

ANALYTICAL REPORT

Material Fresh Tuffaceous Limestone
17-CH-9 460-462'

LRL Sample No. 1M 1043

Z		Weight %	±	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na	± **		±	50.	Sn		±	0.05	±
2.	He	na	±		±	51.	Sb		±	0.4	±
3.	Li		±	19	± 10%	52.	Te		±		±
4.	Be	na	±		±	53.	I		±	2	±
5.	B		±	50	± 50%	55.	Cs		±	0.6	±
6.	C	na	±		±	56.	Ba		±	2560	±
7.	N	na	±		±	57.	La		±	19	±
8.	O	na	±		±	58.	Ce		±	28	±
9.	F	na	±		±	59.	Pr		±	3	±
11.	Na	1.2	± 5%		±	60.	Nd		±	12	±
12.	Mg	0.69	± 2%		±	61.	Pm		±		±
13.	Al	4.21	± 2%		±	62.	Sm		±	4	±
14.	Si	18.99	± 2%		±	63.	Eu		±	0.6	±
15.	P	0.065	± 5%		±	64.	Gd		±	2.5	±
16.	S	1.47	± 5%		±	65.	Tb		±	0.6	±
17.	Cl	na	±		±	66.	Dy		±	4	±
19.	K	0.64	± 5%		±	67.	Ho		±	0.3	±
20.	Ca	15.17	± 2%		±	68.	Er		±	1.5	±
21.	Sc	na	±		±	69.	Tm	na	±		±
22.	Ti	0.41	± 5%		±	70.	Yb		±	2	±
23.	V		±	230	±	71.	Lu		±	<0.05	±
24.	Cr		±	30	± 50%	72.	Hf		±	2	±
25.	Mn	0.02	± 20%		±	73.	Ta	na	±		±
26.	Fe	2.13	± 5%		±	74.	W		±	1.5	±
27.	Co		±	125	±	75.	Re	na	±		±
28.	Ni		±	105	±	76.	Os		±		±
29.	Cu		±	90	±	77.	Ir		±		±
30.	Zn		±	140	±	78.	Pt		±		±
31.	Ga	na	±		±	79.	Au		±		±
32.	Ge	na	±		±	80.	Hg		±		±
33.	As		±	4	±	81.	Tl		±		±
34.	Se		±	0.5	±	82.	Pb		±	2	±
35.	Br		±	2	±	83.	Bi		±		±
37.	Rb		±	13	±	84.	Po		±		±
38.	Sr		±	1900	±	85.	At		±		±
39.	Y		±	42	±	86.	Rn		±		±
40.	Zr		±	115	±	87.	Fr		±		±
41.	Nb		±	9	±	88.	Ra		±		±
42.	Mo		±	9	±	89.	Ac		±		±
43.	Tc		±		±	90.	Th		±	0.5	±
44.	Ru		±	< 0.05	±	91.	Pa		±		±
45.	Rh	na	±		±	92.	U		±	3	±
46.	Pd		±	0.05	±	93.	Np		±		±
47.	Ag		±	0.3	±	94.	Pu		±		±
48.	Cd		±	< 0.05	±	95.	Am		±		±
49.	In		±	< 0.05	±	96.	Cm		±		±
*CO_2		14.3	± 5%		±				±		±
Fe^{+2}/Fe^{+3}		0.65	± 5%		±				±		±

Method of Analysis:

*CO_2 from carbonate

** Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

RL-3635

ANALYTICAL REPORT

Material Slightly weathered siliceous shale LRL Sample No. 121
17-CH-9 648-658'

Z		Weight %	±	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na	± **		±	50.	Sn		±	< 0.05	±
2.	He	na	±		±	51.	Sb		±	< 0.05	±
3.	Li		±	17	± 10%	52.	Te		±	< 0.05	±
4.	Be	na	±		±	53.	I		±	0.5	±
5.	B		±	50	± 50%	55.	Cs		±	0.3	±
6.	C	na	±		±	56.	Ba		±	935	±
7.	N	na	±		±	57.	La		±	8	±
8.	O	na	±		±	58.	Ce		±	9	±
9.	F	na	±		±	59.	Pr		±	2	±
11.	Na	1.4	± 5%		±	60.	Nd		±	7	±
12.	Mg	0.97	± 2%		±	61.	Pm		±		±
13.	Al	4.94	± 2%		±	62.	Sm		±	4	±
14.	Si	20.32	± 2%		±	63.	Eu		±	0.5	±
15.	P	0.064	± 5%		±	64.	Gd		±	2	±
16.	S	0.90	± 5%		±	65.	Tb		±	0.4	±
17.	Cl	na	±		±	66.	Dy		±	2.5	±
19.	K	0.87	± 5%		±	67.	Ho		±	0.5	±
20.	Ca	13.89	± 2%		±	68.	Er		±	1	±
21.	Sc	na	±		±	69.	Tm	na	±		±
22.	Ti	0.56	± 5%		±	70.	Yb		±	2	±
23.	V		±	220	±	71.	Lu		±	0.2	±
24.	Cr		±	30	± 50%	72.	Hf		±	1	±
25.	Mn	0.07	± 20%		±	73.	Ta	na	±		±
26.	Fe	2.73	± 5%		±	74.	W		±		±
27.	Co		±	45	±	75.	Re	na	±		±
28.	Ni		±	20	±	76.	Os		±		±
29.	Cu		±	50	±	77.	Ir		±		±
30.	Zn		±	45	±	78.	Pt		±		±
31.	Ga	na	±		±	79.	Au		±		±
32.	Ge	na	±		±	80.	Hg		±		±
33.	As		±	1	±	81.	Tl		±		±
34.	Se		±	0.4	±	82.	Pb		±	0.8	±
35.	Br		±	0.9	±	83.	Bi		±		±
37.	Rb		±	6	±	84.	Po		±		±
38.	Sr		±	590	±	85.	At		±		±
39.	Y		±	4	±	86.	Rn		±		±
40.	Zr		±	55	±	87.	Fr		±		±
41.	Nb		±	3	±	88.	Ra		±		±
42.	Mo		±	0.6	±	89.	Ac		±		±
43.	Tc		±		±	90.	Th		±	0.1	±
44.	Ru		±	6	±	91.	Pa		±		±
45.	Rh	na	±		±	92.	U		±	0.5	±
46.	Pd		±	0.1	±	93.	Np		±		±
47.	Ag		±	0.3	±	94.	Pu		±		±
48.	Cd		±	< 0.05	±	95.	Am		±		±
49.	In		±	< 0.05	±	96.	Cm		±		±
*CO_2		13.4	± 5%		±				±		±
Fe^{+2}/Fe^{+3}		0.42	± 5%		±				±		±

Method of Analysis:
*CO_2 from carbonate
** Expressed as a percent of the concentration
na - not analyzed

Analytical Lab.
Lab. Sample No.
Date:
Signed:

RL-3695

ANALYTICAL REPORT

Material Shaley limestone — LRL Sample No. 122

17-CH-9 873'

Z	Weight %	± **	Weight PPM	±	Z	Weight %	±	Weight PPM	±
1. H	na				50. Sn			< 0.05	
2. He	na				51. Sb			< 0.05	
3. Li			28	± 5%	52. Te				
4. Be	na				53. I			0.4	
5. B			70	± 50%	55. Cs			0.5	
6. C	na				56. Ba			640	
7. N	na				57. La			13	
8. O	na				58. Ce			19	
9. F	na				59. Pr			2.5	
11. Na	2.0	± 5%			60. Nd			9	
12. Mg	1.91	± 2%			61. Pm				
13. Al	6.40	± 2%			62. Sm			3	
14. Si	25.01	± 2%			63. Eu			0.5	
15. P	0.088	± 5%			64. Gd			2	
16. S	1.34	± 5%			65. Tb			0.3	
17. Cl	na				66. Dy			2	
19. K	1.1	± 5%			67. Ho			0.4	
20. Ca	7.56	± 2%			68. Er			1	
21. Sc	na				69. Tm	na			
22. Ti	0.64	± 5%			70. Yb			0.8	
23. V			155		71. Lu			< 0.05	
24. Cr			40	± 50%	72. Hf			< 0.05	
25. Mn	0.05	± 20%			73. Ta	na			
26. Fe	4.35	± 5%			74. W			< 0.05	
27. Co			35		75. Re	na			
28. Ni			30		76. Os				
29. Cu			50		77. Ir				
30. Zn			45		78. Pt				
31. Ga	na				79. Au				
32. Ge	na				80. Hg				
33. As			1		81. Tl			< 0.05	
34. Se			0.4		82. Pb			2	
35. Br			1		83. Bi				
37. Rb			3		84. Po				
38. Sr			770		85. At				
39. Y			16		86. Rn				
40. Zr			55		87. Fr				
41. Nb			2		88. Ra				
42. Mo			0.9		89. Ac				
43. Tc					90. Th			0.5	
44. Ru			1.5		91. Pa				
45. Rh	na				92. U			0.5	
46. Pd			< 0.05		93. Np				
47. Ag			0.1		94. Pu				
48. Cd			< 0.05		95. Am				
49. In			< 0.05		96. Cm				
*CO_2	4.97	± 5%							
Fe^{+2}/Fe^{+3}	0.63	± 5%							

Method of Analysis:
*CO_2 from carbonate
** Expressed as a percent of the concentration
na - not analyzed

Analytical Lab. _____
Lab. Sample No. _____
Date: _____
Signed: _____

RL-3635

ANALYTICAL REPORT

Material Fresh Tuffaceous Limestone
17-CH-10 363.7 - 364.2'
and 365.3 - 366.5'

LRL Sample No. 1M 1213

Z		Weight %		Weight PPM		Z		Weight %		Weight PPM	
1.	H	na	± **		±	50.	Sn		±	0.7	±
2.	He	na	±		±	51.	Sb		±	0.1	±
3.	Li		±	8	± 10%	52.	Te		±		±
4.	Be	na	±		±	53.	I		±	1	±
5.	B		±	< 5	±	55.	Cs		±	1	±
6.	C	na	±		±	56.	Ba		±	680	±
7.	N	na	±		±	57.	La		±	55	±
8.	O	na	±		±	58.	Ce		±	9	±
9.	F	na	±		±	59.	Pr		±	9	±
11.	Na	0.28	± 5%		±	60.	Nd		±	35	±
12.	Mg	0.32	± 2%		±	61.	Pm		±		±
13.	Al	0.80	± 2%		±	62.	Sm		±	12	±
14.	Si	20.11	± 2%		±	63.	Eu		±	3	±
15.	P	0.036	± 5%		±	64.	Gd		±	8	±
16.	S	0.20	± 5%		±	65.	Tb		±	1	±
17.	Cl	na	±		±	66.	Dy		±	8	±
19.	K	0.32	± 5%		±	67.	Ho		±	1	±
20.	Ca	21.26	± 2%		±	68.	Er		±	3	±
21.	Sc	na	±		±	69.	Tm	na	±		±
22.	Ti	0.10	± 5%		±	70.	Yb		±	4	±
23.	V		±	110	±	71.	Lu		±	0.2	±
24.	Cr		±	< 10	±	72.	Hf		±	0.7	±
25.	Mn	0.02	± 20%		±	73.	Ta	na	±		±
26.	Fe	0.53	± 5%		±	74.	W		±	0.3	±
27.	Co		±	80	±	75.	Re	na	±		±
28.	Ni		±	25	±	76.	Os		±		±
29.	Cu		±	110	±	77.	Ir		±		±
30.	Zn		±	175	±	78.	Pt		±		±
31.	Ga	na	±		±	79.	Au		±		±
32.	Ge	na	±		±	80.	Hg		±		±
33.	As		±	1.5	±	81.	Tl		±		±
34.	Se		±	2.5	±	82.	Pb		±	3	±
35.	Br		±	4	±	83.	Bi		±		±
37.	Rb		±	13	±	84.	Po		±		±
38.	Sr		±	455	±	85.	At		±		±
39.	Y		±	65	±	86.	Rn		±		±
40.	Zr		±	55	±	87.	Fr		±		±
41.	Nb		±	1.5	±	88.	Ra		±		±
42.	Mo		±	7	±	89.	Ac		±		±
43.	Tc		±		±	90.	Th		±	5	±
44.	Ru		±		±	91.	Pa		±		±
45.	Rh	na	±		±	92.	U		±		±
46.	Pd		±	1	±	93.	Np		±		±
47.	Ag		±	0.3	±	94.	Pu		±		±
48.	Cd		±	2	±	95.	Am		±		±
49.	In		±	0.1	±	96.	Cm		±		±
*CO_2		21.5	± 5%		±				±		±
Fe^{+2}/Fe^{+3}		0.76	± 5%		±				±		±

Method of Analysis:
*CO_2 from carbonate
** Expressed as a percent of the concentration
na - not analyzed

Analytical Lab. _____
Lab. Sample No. _____
Date: _____
Signed: _____

RL-3635

ANALYTICAL REPORT

Material: Fresh tuffaceous limestone — LRL Sample No. 116

17-CH-10 495'

Z		Weight %	**	Weight PPM		Z		Weight %		Weight PPM	
1.	H	na	±		±	50.	Sn		±	< 0.05	±
2.	He	na	±		±	51.	Sb		±	< 0.05	±
3.	Li		±	10	±10%	52.	Te		±	< 0.05	±
4.	Be	na	±		±	53.	I		±	0.1	±
5.	B		±	5	±50%	55.	Cs		±	0.5	±
6.	C	na	±		±	56.	Ba		±	1850	±
7.	N	na	±		±	57.	La		±	18	±
8.	O	na	±		±	58.	Ce		±	12	±
9.	F	na	±		±	59.	Pr		±	3	±
11.	Na	1.1	± 5%		±	60.	Nd		±	10	±
12.	Mg	1.02	± 2%		±	61.	Pm		±		±
13.	Al	4.13	± 2%		±	62.	Sm		±	4	±
14.	Si	22.69	± 2%		±	63.	Eu		±	0.7	±
15.	P	0.026	± 5%		±	64.	Gd		±	3	±
16.	S	0.13	± 5%		±	65.	Tb		±	0.7	±
17.	Cl	na	±		±	66.	Dy		±	2	±
19.	K	0.81	± 5%		±	67.	Ho		±	0.4	±
20.	Ca	13.74	± 2%		±	68.	Er		±	1	±
21.	Sc	na	±		±	69.	Tm	na	±		±
22.	Ti	0.18	± 5%		±	70.	Yb		±	2	±
23.	V		±	48	±	71.	Lu		±	0.2	±
24.	Cr		±	10	± 50%	72.	Hf		±	0.4	±
25.	Mn	0.08	± 10%		±	73.	Ta	na	±		±
26.	Fe	2.14	± 5%		±	74.	W		±	2	±
27.	Co		±	19	±	75.	Re	na	±		±
28.	Ni		±	5	±	76.	Os		±		±
29.	Cu		±	38	±	77.	Ir		±		±
30.	Zn		±	120	±	78.	Pt		±	0.6	±
31.	Ga	na	±		±	79.	Au		±		±
32.	Ge	na	±		±	80.	Hg		±		±
33.	As		±	0.1	±	81.	Tl		±		±
34.	Se		±	0.4	±	82.	Pb		±	1	±
35.	Br		±	0.5	±	83.	Bi		±		±
37.	Rb		±	4	±	84.	Po		±		±
38.	Sr		±	400	±	85.	At		±		±
39.	Y		±	53	±	86.	Rn		±		±
40.	Zr		±	50	±	87.	Fr		±		±
41.	Nb		±	4	±	88.	Ra		±		±
42.	Mo		±		±	89.	Ac		±		±
43.	Tc		±		±	90.	Th		±	0.5	±
44.	Ru		±	1.5	±	91.	Pa		±		±
45.	Rh	na	±		±	92.	U		±	0.3	±
46.	Pd		±	0.1	±	93.	Np		±		±
47.	Ag		±	0.1	±	94.	Pu		±		±
48.	Cd		±	< 0.05	±	95.	Am		±		±
49.	In		±	< 0.05	±	96.	Cm		±		±
*CO_2		13.3	± 5%		±	Free H_2O		4.10	± 5%		±
Fe^{+2}/Fe^{+3}		0.95	± 5%		±	Bound H_2O		2.46	± 5%		±

Method of Analysis:

*CO_2 from carbonate

** Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

RL-3635

ANALYTICAL REPORT

Material: Fresh to slightly weathered diabase

17-CH-11 86.1-89.0'

LRL Sample No. 1M1411

Z		Weight %	±	Weight PPM	±
1.	H	na	± **		±
2.	He	na	±		±
3.	Li		±	10	± 10%
4.	Be	na	±		±
5.	B		±	< 5	±
6.	C	na	±		±
7.	N	na	±		±
8.	O	na	±		±
9.	F	na	±		±
11.	Na	8.1	± 5%		±
12.	Mg	6.77	± 5%		±
13.	Al	8.42	± 5%		±
14.	Si	22.65	± 5%		±
15.	P	0.008	± 10%		±
16.	S	0.009	± 10%		±
17.	Cl	na	±		±
19.	K	0.069	± 5%		±
20.	Ca	6.98	± 5%		±
21.	Sc	na	±		±
22.	Ti	0.98	± 5%		±
23.	V		±	170	±
24.	Cr		±	400	± 50%
25.	Mn	0.04	± 20%		±
26.	Fe	5.78	± 5%		±
27.	Co		±	14	±
28.	Ni		±	65	±
29.	Cu		±	25	±
30.	Zn		±	75	±
31.	Ga	na	±		±
32.	Ge	na	±		±
33.	As		±	0.1	±
34.	Se		±	0.3	±
35.	Br		±	0.6	±
37.	Rb		±	0.1	±
38.	Sr		±	60	±
39.	Y		±	16	±
40.	Zr		±	16	±
41.	Nb		±	0.1	±
42.	Mo		±		±
43.	Tc		±		±
44.	Ru		±	2	±
45.	Rh	na	±		±
46.	Pd		±		±
47.	Ag		±		±
48.	Cd		±		±
49.	In		±	< 0.05	±
	*CO_2	0.14	± 5%		±
	Fe^{+2}/Fe^{+3}	1.82	± 5%		±

Z		Weight %	±	Weight PPM	±
50.	Sn		±	0.05	±
51.	Sb		±	< 0.05	±
52.	Te		±	< 0.05	±
53.	I		±		±
55.	Cs		±	0.1	±
56.	Ba		±	14	±
57.	La		±	1	±
58.	Ce		±	3	±
59.	Pr		±	0.5	±
60.	Nd		±	2.5	±
61.	Pm		±		±
62.	Sm		±	1	±
63.	Eu		±	0.3	±
64.	Gd		±	0.5	±
65.	Tb		±	0.3	±
66.	Dy		±	1	±
67.	Ho		±	0.3	±
68.	Er		±	1	±
69.	Tm	na	±		±
70.	Yb		±	1	±
71.	Lu		±		±
72.	Hf		±		±
73.	Ta	na	±		±
74.	W		±		±
75.	Re	na	±		±
76.	Os		±		±
77.	Ir		±		±
78.	Pt		±		±
79.	Au		±		±
80.	Hg		±		±
81.	Tl		±		±
82.	Pb		±	0.3	±
83.	Bi		±		±
84.	Po		±		±
85.	At		±		±
86.	Rn		±		±
87.	Fr		±		±
88.	Ra		±		±
89.	Ac		±		±
90.	Th		±		±
91.	Pa		±		±
92.	U		±		±
93.	Np		±		±
94.	Pu		±		±
95.	Am		±		±
96.	Cm		±		±
			±		±
			±		±

Method of Analysis:

*CO_2 from carbonate

** Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

ANALYTICAL REPORT

Material: Porphyritic amygdaloidal altered and slightly weathered basalt

LRL Sample No. 1 M 1419

17-CH-11 496.5-499.0'

Z		Weight %	±	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na	**			50.	Sn			< 0.05	
2.	He	na				51.	Sb			< 0.05	
3.	Li			9	±10%	52.	Te			< 0.05	
4.	Be	na				53.	I			0.1	
5.	B			7	±50%	55.	Cs			0.1	
6.	C	na				56.	Ba			15	
7.	N	na				57.	La			4	
8.	O	na				58.	Ce			8	
9.	F	na				59.	Pr			2	
11.	Na	2.1	± 5%			60.	Nd			6	
12.	Mg	2.43	± 5%			61.	Pm				
13.	Al	9.25	± 5%			62.	Sm			2	
14.	Si	23.14	± 5%			63.	Eu			0.3	
15.	P	0.010	±10%			64.	Gd			1	
16.	S	0.012	±10%			65.	Tb			0.4	
17.	Cl	na				66.	Dy			1.5	
19.	K	0.093	± 5%			67.	Ho			0.3	
20.	Ca	6.29	± 5%			68.	Er			0.7	
21.	Sc	na				69.	Tm	na			
22.	Ti	0.69	± 5%			70.	Yb			1	
23.	V			620		71.	Lu				
24.	Cr			< 10		72.	Hf			< 0.05	
25.	Mn	0.03	±20%	1000		73.	Ta	na			
26.	Fe	6.24	± 5%			74.	W				
27.	Co			35		75.	Re	na			
28.	Ni			14		76.	Os				
29.	Cu			115		77.	Ir				
30.	Zn			140		78.	Pt				
31.	Ga	na				79.	Au				
32.	Ge	na				80.	Hg				
33.	As			0.4		81.	Tl				
34.	Se			0.8		82.	Pb			0.6	
35.	Br			2		83.	Bi				
37.	Rb			0.3		84.	Po				
38.	Sr			80		85.	At				
39.	Y			21		86.	Rn				
40.	Zr			30		87.	Fr				
41.	Nb			0.2		88.	Ra				
42.	Mo			0.8		89.	Ac				
43.	Tc					90.	Th			< 0.05	
44.	Ru			9		91.	Pa				
45.	Rh	na				92.	U				
46.	Pd			< 0.05		93.	Np				
47.	Ag			< 0.05		94.	Pu				
48.	Cd					95.	Am				
49.	In			< 0.05		96.	Cm				
*CO_2		0.36	± 5%								
Fe^{+2}/Fe^{+3}		0.93	± 5%								

Method of Analysis:

*CO_2 from carbonate

**Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

RL-3635

ANALYTICAL REPORT

Material: Altered and weathered porphyritic basalt

LRL Sample No. 1 M 1113

17-CH-11 901.8-903.2'

Z		Weight %	±	**	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na					50.	Sn			0.3	
2.	He	na					51.	Sb				
3.	Li				15	± 10%	52.	Te				
4.	Be	na					53.	I				
5.	B				5		55.	Cs				
6.	C	na					56.	Ba			35	
7.	N	na					57.	La			9	
8.	O	na					58.	Ce			20	
9.	F	na					59.	Pr			5	
11.	Na	2.0	± 5%				60.	Nd			20	
12.	Mg	3.08	± 2%				61.	Pm				
13.	Al	9.75	± 2%				62.	Sm			10	
14.	Si	21.58	± 2%				63.	Eu			2	
15.	P	0.051	± 5%				64.	Gd			6	
16.	S	0.022	± 5%				65.	Tb			1	
17.	Cl	na					66.	Dy			5	
19.	K	0.11	± 5%				67.	Ho			3	
20.	Ca	5.92	± 5%				68.	Er			4	
21.	Sc	na					69.	Tm	na			
22.	Ti	0.74	± 5%				70.	Yb			3	
23.	V				350		71.	Lu			1	
24.	Cr				< 10		72.	Hf				
25.	Mn	0.10	± 10%				73.	Ta	na			
26.	Fe	6.98	± 5%				74.	W				
27.	Co				20		75.	Re	na			
28.	Ni				30		76.	Os				
29.	Cu				65		77.	Ir				
30.	Zn				75		78.	Pt				
31.	Ga	na					79.	Au				
32.	Ge	na					80.	Hg				
33.	As				0.6		81.	Tl				
34.	Se				0.8		82.	Pb			1	
35.	Br				1		83.	Bi				
37.	Rb				0.6		84.	Po				
38.	Sr				75		85.	At				
39.	Y				35		86.	Rn				
40.	Zr				60		87.	Fr				
41.	Nb				0.5		88.	Ra				
42.	Mo				3		89.	Ac				
43.	Tc						90.	Th				
44.	Ru				15		91.	Pa				
45.	Rh	na					92.	U				
46.	Pd						93.	Np				
47.	Ag						94.	Pu				
48.	Cd						95.	Am				
49.	In				0.3		96.	Cm				
	*CO_2	0.39	± 5%									
Fe^{+2}/Fe^{+3}		0.87	± 5%									

Method of Analysis:

*CO_2 from carbonate

** Expressed as a percent of the concentration

na - not analyzed

Analytical Lab.

Lab. Sample No.

Date:

Signed:

RL-3635

ANALYTICAL REPORT

Material Fresh altered tuff — LRL Sample No. 1 M 1475

17-CH-11 925.8-928.7'

Z	Weight %	± **	Weight PPM	±	Z	Weight %	±	Weight PPM	±
1. H	na				50. Sn			0.05	
2. He	na				51. Sb				
3. Li			9	± 10%	52. Te				
4. Be			0.5		53. I				
5. B			20	± 50%	55. Cs			0.1	
6. C	na				56. Ba			200	± 50%
7. N	na				57. La			5	
8. O	na				58. Ce			20	
9. F	na				59. Pr			4	
11. Na	1.8	± 5%			60. Nd			15	
12. Mg	1.68	± 2%			61. Pm				
13. Al	7.30	± 2%			62. Sm			5	
14. Si	26.65	± 2%			63. Eu			1	
15. P	0.038	± 5%			64. Gd			6	
16. S	0.019	± 5%			65. Tb			0.5	
17. Cl	na				66. Dy			4	
19. K	0.47	± 5%			67. Ho			1	
20. Ca	5.13	± 2%			68. Er			4	
21. Sc			25	± 50%	69. Tm	na			
22. Ti	0.91	± 5%			70. Yb			3	
23. V			250	± 50%	71. Lu			0.4	
24. Cr			20	± 50%	72. Hf			2	
25. Mn	0.06	± 20%			73. Ta	na			
26. Fe	6.20	± 5%			74. W				
27. Co					75. Re	na			
28. Ni			15	± 50%	76. Os				
29. Cu			120	± 50%	77. Ir				
30. Zn			40	± 50%	78. Pt				
31. Ga			20	± 50%	79. Au				
32. Ge	na				80. Hg				
33. As			2		81. Tl				
34. Se			0.3		82. Pb			2	
35. Br			6		83. Bi				
37. Rb			2		84. Po				
38. Sr			75	± 50%	85. At				
39. Y			16	± 50%	86. Rn				
40. Zr			150	± 50%	87. Fr				
41. Nb			0.5		88. Ra				
42. Mo			1		89. Ac				
43. Tc					90. Th			1	
44. Ru			7		91. Pa				
45. Rh	na				92. U				
46. Pd					93. Np				
47. Ag			0.1		94. Pu				
48. Cd					95. Am				
49. In					96. Cm				
*CO_2	0.24	± 5%							
Fe^{+2}/Fe^{+3}	0.74	± 5%							

Method of Analysis:

* CO_2 from carbonate

** Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

RL-3635

ANALYTICAL REPORT

Material Fresh tuffaceous sandstone 17-CH-12 and 118.4-119.1' 120.2-120.8'

LRL Sample No. 1 M 1262

Z		Weight %	± **	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na				50.	Sn				
2.	He	na				51.	Sb				
3.	Li			12	± 10%	52.	Te				
4.	Be	na				53.	I				
5.	B			5		55.	Cs			0.1	
6.	C	na				56.	Ba			400	
7.	N	na				57.	La			6	
8.	O	na				58.	Ce			12	
9.	F	na				59.	Pr			1.5	
11.	Na	1.6	± 5%			60.	Nd			6	
12.	Mg	2.44	± 2%			61.	Pm				
13.	Al	10.44	± 2%			62.	Sm			4	
14.	Si	23.07	± 2%			63.	Eu			2	
15.	P	0.009	± 10%			64.	Gd			4	
16.	S	0.041	± 5%			65.	Tb			0.9	
17.	Cl	na				66.	Dy			4	
19.	K	0.40	± 5%			67.	Ho			3	
20.	Ca	6.29	± 2%			68.	Er			2	
21.	Sc	na				69.	Tm	na			
22.	Ti	0.62	± 5%			70.	Yb			0.6	
23.	V			200		71.	Lu				
24.	Cr			45	± 50%	72.	Hf				
25.	Mn	0.04	± 20%			73.	Ta	na			
26.	Fe	5.42	± 5%			74.	W			1	
27.	Co			18		75.	Re	na			
28.	Ni			12		76.	Os				
29.	Cu			85		77.	Ir				
30.	Zn			130		78.	Pt				
31.	Ga	na				79.	Au				
32.	Ge	na				80.	Hg				
33.	As			0.3		81.	Tl				
34.	Se			0.2		82.	Pb			2	
35.	Br			1.5		83.	Bi				
37.	Rb			1.5		84.	Po				
38.	Sr			450		85.	At				
39.	Y			18		86.	Rn				
40.	Zr			30		87.	Fr				
41.	Nb			0.3		88.	Ra				
42.	Mo					89.	Ac				
43.	Tc					90.	Th				
44.	Ru			2		91.	Pa				
45.	Rh	na				92.	U				
46.	Pd					93.	Np				
47.	Ag					94.	Pu				
48.	Cd					95.	Am				
49.	In					96.	Cm				
* CO_2		0.14	± 5%								
Fe^{+2}/Fe^{+3}		0.25	± 5%								

Method of Analysis:

* CO_2 from carbonate

** Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

RL-3635

ANALYTICAL REPORT

Material: Fresh tuffaceous siltstone

LRL Sample No. 1 M 1281

17-CH-12 179.8-182.3'

Z		Weight %	± **	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na				50.	Sn			0.1	
2.	He	na				51.	Sb				
3.	Li			14	± 10%	52.	Te				
4.	Be	na				53.	I			0.2	
5.	B			10	± 50%	55.	Cs			0.05	
6.	C	na				56.	Ba			550	
7.	N	na				57.	La			5	
8.	O	na				58.	Ce			12	
9.	F	na				59.	Pr			2	
11.	Na	1.7	± 5%			60.	Nd			9	
12.	Mg	2.77	± 5%			61.	Pm				
13.	Al	9.70	± 2%			62.	Sm			4	
14.	Si	24.24	± 2%			63.	Eu			0.4	
15.	P	0.031	± 5%			64.	Gd			3	
16.	S	0.109	± 5%			65.	Tb			0.4	
17.	Cl	na				66.	Dy			3	
19.	K	0.44	± 5%			67.	Ho			0.5	
20.	Ca	5.66	± 2%			68.	Er			1	
21.	Sc	na				69.	Tm	na			
22.	Ti	0.74	± 5%			70.	Yb			2.5	
23.	V			850		71.	Lu				
24.	Cr			20	± 50%	72.	Hf			2	
25.	Mn	0.08	± 10%			73.	Ta	na			
26.	Fe	6.71	± 5%			74.	W			0.5	
27.	Co			10		75.	Re	na			
28.	Ni			11		76.	Os				
29.	Cu			235		77.	Ir				
30.	Zn			75		78.	Pt				
31.	Ga	na				79.	Au				
32.	Ge	na				80.	Hg				
33.	As			0.4		81.	Tl				
34.	Se			0.8		82.	Pb			2	
35.	Br			1		83.	Bi				
37.	Rb			5		84.	Po				
38.	Sr			210		85.	At				
39.	Y			35		86.	Rn				
40.	Zr			50		87.	Fr				
41.	Nb			0.3		88.	Ra				
42.	Mo					89.	Ac				
43.	Tc					90.	Th				
44.	Ru			5		91.	Pa				
45.	Rh	na				92.	U				
46.	Pd					93.	Np				
47.	Ag					94.	Pu				
48.	Cd					95.	Am				
49.	In					96.	Cm				
*CO_2		0.14	± 5%								
Fe^{+2}/Fe^{+3}		0.20	± 5%								

Method of Analysis:

*CO_2 from carbonate

** Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

RL-3635

ANALYTICAL REPORT

Material Agglomerate
17-CH-12 288.2 - 289.0'

LRL Sample No. 1M 1073

Z		Weight %	±	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na	± **		±	50.	Sn		±		±
2.	He	na	±		±	51.	Sb		±		±
3.	Li		±	8	± 10%	52.	Te		±		±
4.	Be	na	±		±	53.	I		±	0.3	±
5.	B		±	< 5	±	55.	Cs		±		±
6.	C	na	±		±	56.	Ba		±	55	±
7.	N	na	±		±	57.	La		±	1.5	±
8.	O	na	±		±	58.	Ce		±	8	±
9.	F	na	±		±	59.	Pr		±	0.8	±
11.	Na	1.4	± 5%		±	60.	Nd		±	2	±
12.	Mg	3.02	± 2%		±	61.	Pm		±		±
13.	Al	11.52	± 2%		±	62.	Sm		±	2	±
14.	Si	20.83	± 2%		±	63.	Eu		±	0.7	±
15.	P	0.005	± 20%		±	64.	Gd		±	1	±
16.	S	0.008	± 10%		±	65.	Tb		±	0.4	±
17.	Cl	na	±		±	66.	Dy		±	1	±
19.	K	0.17	± 5%		±	67.	Ho		±	0.4	±
20.	Ca	8.86	± 2%		±	68.	Er		±	2	±
21.	Sc	na	±		±	69.	Tm	na	±		±
22.	Ti	0.59	± 5%		±	70.	Yb		±		±
23.	V		±	350	±	71.	Lu		±		±
24.	Cr		±	35	± 50%	72.	Hf		±		±
25.	Mn	0.06	± 20%		±	73.	Ta	na	±		±
26.	Fe	6.13	± 5%		±	74.	W		±		±
27.	Co		±	12	±	75.	Re	na	±		±
28.	Ni		±	20	±	76.	Os		±	1	±
29.	Cu		±	40	±	77.	Ir		±		±
30.	Zn		±	60	±	78.	Pt		±		±
31.	Ga	na	±		±	79.	Au		±		±
32.	Ge	na	±		±	80.	Hg		±		±
33.	As		±	0.1	±	81.	Tl		±		±
34.	Se		±	0.5	±	82.	Pb		±	0.6	±
35.	Br		±	2	±	83.	Bi		±		±
37.	Rb		±	0.7	±	84.	Po		±		±
38.	Sr		±	160	±	85.	At		±		±
39.	Y		±	12	±	86.	Rn		±		±
40.	Zr		±	25	±	87.	Fr		±		±
41.	Nb		±	0.2	±	88.	Ra		±		±
42.	Mo		±		±	89.	Ac		±		±
43.	Tc		±		±	90.	Th		±		±
44.	Ru	na	±		±	91.	Pa		±		±
45.	Rh		±		±	92.	U		±		±
46.	Pd		±		±	93.	Np		±		±
47.	Ag		±		±	94.	Pu		±		±
48.	Cd		±		±	95.	Am		±		±
49.	In		±	0.2	±	96.	Cm		±		±
*CO_2		0.15	± 5%		±				±		±
Fe^{+2}/Fe^{+3}		0.39	± 5%		±				±		±

Method of Analysis:
* CO_2 from carbonate
** Expressed as a percent of the concentration
na - not analyzed

Analytical Lab.
Lab. Sample No.
Date:
Signed:

RL-3635

ANALYTICAL REPORT

Material: Agglomerate with tuffaceous matrix — 17-CH-12 385.6-387.1'

LRL Sample No. 1 M 1328

Z		Weight %	±	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na	**			50.	Sn			< 0.05	
2.	He	na				51.	Sb			0.2	
3.	Li			14	±10%	52.	Te			0.1	
4.	Be	na				53.	I				
5.	B			5		55.	Cs			0.3	
6.	C	na				56.	Ba			32	
7.	N	na				57.	La			2	
8.	O	na				58.	Ce			5	
9.	F	na				59.	Pr			0.8	
11.	Na	1.0	± 5%			60.	Nd			4.5	
12.	Mg	3.04	± 2%			61.	Pm				
13.	Al	10.11	± 2%			62.	Sm			3	
14.	Si	21.90	± 2%			63.	Eu			0.5	
15.	P	0.003	± 50%			64.	Gd			2	
16.	S	0.006	± 10%			65.	Tb			0	
17.	Cl	na				66.	Dy			3	
19.	K	0.082	± 5%			67.	Ho			0.5	
20.	Ca	8.10	± 2%			68.	Er			1.5	
21.	Sc	na				69.	Tm	na			
22.	Ti	0.59	± 5%			70.	Yb			2	
23.	V			155		71.	Lu			0.2	
24.	Cr			90	±50%	72.	Hf			1	
25.	Mn	0.08	± 10%			73.	Ta	na			
26.	Fe	7.18	± 5%			74.	W			0.7	
27.	Co			8		75.	Re	na			
28.	Ni			16		76.	Os				
29.	Cu			25		77.	Ir				
30.	Zn			75		78.	Pt				
31.	Ga	na				79.	Au				
32.	Ge	na				80.	Hg				
33.	As			0.2		81.	Tl				
34.	Se			1.5		82.	Pb			1	
35.	Br			1		83.	Bi				
37.	Rb			0.1		84.	Po				
38.	Sr			90		85.	At				
39.	Y			10		86.	Rn				
40.	Zr			12		87.	Fr				
41.	Nb			0.5		88.	Ra				
42.	Mo			1		89.	Ac				
43.	Tc					90.	Th				
44.	Ru			7		91.	Pa				
45.	Rh	na				92.	U				
46.	Pd			< 0.05		93.	Np				
47.	Ag			< 0.05		94.	Pu				
48.	Cd					95.	Am				
49.	In			0.1		96.	Cm				
*CO_2		0.16	± 5%								
Fe^{+2}/Fe^{2+3}		0.37	± 5%								

Method of Analysis:
*CO_2 from carbonate
**Expressed as a percent of the concentration
na - not analyzed

Analytical Lab. _____
Lab. Sample No. _____
Date: _____
Signed: _____

RL-3635

ANALYTICAL REPORT

Material Fresh tuffaceous sandstone LRL Sample No. 123

17-CH-12 970'

Z	Weight %	± **	Weight PPM	±	Z	Weight %	±	Weight PPM	±
1. H	na				50. Sn			< 0.05	
2. He	na				51. Sb				
3. Li			17	± 10%	52. Te				
4. Be	na				53. I				
5. B			25	± 50%	55. Cs			0.5	
6. C	na				56. Ba			190	
7. N	na				57. La			11	
8. O	na				58. Ce			12	
9. F	na				59. Pr			3	
11. Na	3.1	±5%			60. Nd			10	
12. Mg	2.15	±2%			61. Pm				
13. Al	10.20	±2%			62. Sm			4	
14. Si	24.61	±2%			63. Eu			0.5	
15. P	0.032	±5%			64. Gd			2	
16. S	0.079	±5%			65. Tb			0.3	
17. Cl	na				66. Dy			2	
19. K	0.69	±5%			67. Ho			0.3	
20. Ca	4.99	±2%			68. Er			1	
21. Sc	na				69. Tm	na			
22. Ti	0.56	±5%			70. Yb			0.8	
23. V			170		71. Lu			< 0.05	
24. Cr			60	± 50%	72. Hf			2	
25. Mn	0.05	±20%			73. Ta	na			
26. Fe	5.37	± 5%			74. W				
27. Co			9		75. Re	na			
28. Ni			8		76. Os				
29. Cu			50		77. Ir				
30. Zn			22		78. Pt				
31. Ga	na				79. Au				
32. Ge	na				80. Hg				
33. As			0.2		81. Tl				
34. Se			0.3		82. Pb			0.9	
35. Br			0.6		83. Bi				
37. Rb			21		84. Po				
38. Sr			75		85. At				
39. Y			17		86. Rn				
40. Zr			32		87. Fr				
41. Nb			0.2		88. Ra				
42. Mo					89. Ac				
43. Tc					90. Th			0.5	
44. Ru			2		91. Pa				
45. Rh	na				92. U			0.2	
46. Pd			< 0.05		93. Np				
47. Ag			< 0.05		94. Pu				
48. Cd					95. Am				
49. In			< 0.05		96. Cm				
*CO_2	0.20	±5%							
Fe^{+2}/Fe^{+3}	0.31	±5%							

Method of Analysis:

* CO_2 from carbonate

** Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

RL-3635

ANALYTICAL REPORT

Material: Fresh Tuffaceous Limestone

LRL Sample No. 1M 1248

17-CH-13 208.2 - 209.8'

Z		Weight %		Weight PPM		Z		Weight %		Weight PPM	
1.	H	na	± **		±	50.	Sn		±	<0.05	±
2.	He	na	±		±	51.	Sb		±	<0.05	±
3.	Li		±	17	± 10%	52.	Te		±		±
4.	Be	na	±		±	53.	I		±	0.4	±
5.	B		±	15	± 50%	55.	Cs		±	0.5	±
6.	C	na	±		±	56.	Ba		±	2300	±
7.	N	na	±		±	57.	La		±	21	±
8.	O	na	±		±	58.	Ce		±	29	±
9.	F	na	±		±	59.	Pr		±	4	±
11.	Na	1.4	± 5%		±	60.	Nd		±	9	±
12.	Mg	1.03	± 2%		±	61.	Pm		±		±
13.	Al	4.33	± 2%		±	62.	Sm		±	4	±
14.	Si	18.85	± 2%		±	63.	Eu		±	1	±
15.	P	0.010	± 10%		±	64.	Gd		±	4	±
16.	S	0.19	± 5%		±	65.	Tb		±	1	±
17.	Cl	na	±		±	66.	Dy		±	4	±
19.	K	0.93	± 5%		±	67.	Ho		±	0.6	±
20.	Ca	15.75	± 2%		±	68.	Er		±	2	±
21.	Sc	na	±		±	69.	Tm	na	±		±
22.	Ti	0.51	± 5%		±	70.	Yb		±	2	±
23.	V		±	192	±	71.	Lu		±	0.3	±
24.	Cr		±	20	± 50%	72.	Hf		±	1.5	±
25.	Mn	0.02	± 20%		±	73.	Ta	na	±		±
26.	Fe	2.52	± 5%		±	74.	W		±	0.5	±
27.	Co		±	58	±	75.	Re	na	±		±
28.	Ni		±	21	±	76.	Os		±		±
29.	Cu		±	96	±	77.	Ir		±		±
30.	Zn		±	105	±	78.	Pt		±		±
31.	Ga	na	±		±	79.	Au		±		±
32.	Ge	na	±		±	80.	Hg		±		±
33.	As		±	0.65	±	81.	Tl		±		±
34.	Se		±	< 0.05	±	82.	Pb		±	1.5	±
35.	Br		±	2	±	83.	Bi		±		±
37.	Rb		±	6	±	84.	Po		±		±
38.	Sr		±	1900	±	85.	At		±		±
39.	Y		±	42	±	86.	Rn		±		±
40.	Zr		±	62	±	87.	Fr		±		±
41.	Nb		±	3	±	88.	Ra		±		±
42.	Mo		±		±	89.	Ac		±		±
43.	Tc		±		±	90.	Th		±	0.5	±
44.	Ru		±	4	±	91.	Pa		±		±
45.	Rh	na	±		±	92.	U		±	0.8	±
46.	Pd		±	0.2	±	93.	Np		±		±
47.	Ag		±		±	94.	Pu		±		±
48.	Cd		±	< 0.05	±	95.	Am		±		±
49.	In		±	< 0.05	±	96.	Cm		±		±
*CO_2		14.6	± 5%		±				±		±
Fe^{+2}/Fe^{+3}		0.36	± 5%		±				±		±

Method of Analysis:

*CO_2 from carbonate

** Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

RL-3635

ANALYTICAL REPORT

Material: Moderately weathered calcareous shale, 17-CH-13 321'

LRL Sample No. 222/64

Z	Weight %	±	Weight PPM	±	Z	Weight %	±	Weight PPM	±
1. H	na				50. Sn			0.05	
2. He	na				51. Sb			0.05	
3. Li			96	± 5%	52. Te				
4. Be	na				53. I			10	
5. B			50	± 50%	55. Cs			2	
6. C	na				56. Ba			520	
7. N	na				57. La			8	
8. O	na				58. Ce			13	
9. F	na				59. Pr			2	
11. Na	1.3	± 5%			60. Nd			8	
12. Mg	1.81	± 2%			61. Pm				
13. Al	8.74	± 2%			62. Sm			3	
14. Si	22.60	± 2%			63. Eu			0.5	
15. P	0.061	± 5%			64. Gd			1	
16. S	1.46	± 5%			65. Tb			0.3	
17. Cl	na				66. Dy			2	
19. K	1.4	± 5%			67. Ho			0.2	
20. Ca	4.52	± 2%			68. Er			1	
21. Sc	na				69. Tm	na			
22. Ti	0.75	± 5%			70. Yb			1	
23. V			420		71. Lu				
24. Cr			100	± 50%	72. Hf				
25. Mn	0.05	± 20%			73. Ta	na			
26. Fe	5.56	± 5%			74. W			1	
27. Co			12		75. Re	na			
28. Ni			75		76. Os			0.5	
29. Cu			60		77. Ir				
30. Zn			60		78. Pt				
31. Ga	na				79. Au				
32. Ge	na				80. Hg				
33. As			2		81. Tl				
34. Se			1		82. Pb			2	
35. Br			20		83. Bi				
37. Rb			8		84. Po				
38. Sr			260		85. At				
39. Y			20		86. Rn				
40. Zr			80		87. Fr				
41. Nb			5		88. Ra				
42. Mo			3		89. Ac				
43. Tc					90. Th			2	
44. Ru			2		91. Pa				
45. Rh	na				92. U			1	
46. Pd					93. Np				
47. Ag			0.2		94. Pu				
48. Cd					95. Am				
49. In					96. Cm				
*CO_2	5.90	± 5%							
Fe^{+2}/Fe^{+3}	1.58	± 5%							

Method of Analysis:

* CO_2 From carbonate

** Expressed as a percent of the concentration

na - Not analyzed

Analytical Lab.

Lab. Sample No.

Date:

Signed:

RL-3635

ANALYTICAL REPORT

Material Fresh shale
17-CH-13 781'

LRL Sample No. 112

Z		Weight %	± **	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na				50.	Sn			0.05	
2.	He	na				51.	Sb			0.5	
3.	Li			94	± 5%	52.	Te				
4.	Be			0.5	± 50%	53.	I			30	
5.	B			80	± 50%	55.	Cs			2	
6.	C	na				56.	Ba			400	± 50%
7.	N	na				57.	La			5	
8.	O	na				58.	Ce			21	
9.	F	na				59.	Pr			3	
11.	Na	1.4	± 5%			60.	Nd			4	
12.	Mg	1.96	± 2%			61.	Pm				
13.	Al	8.74	± 2%			62.	Sm			3	
14.	Si	21.84	± 2%			63.	Eu			0.4	
15.	P	0.078	± 5%			64.	Gd			2	
16.	S	1.83	± 5%			65.	Tb			0.3	
17.	Cl	na				66.	Dy			3	
19.	K	1.2	± 5%			67.	Ho			0.3	
20.	Ca	5.26	± 2%			68.	Er			1	
21.	Sc			20	± 50%	69.	Tm	na			
22.	Ti	0.73	± 5%			70.	Yb			1.5	
23.	V			100	± 50%	71.	Lu			0.2	
24.	Cr			100	± 50%	72.	Hf			1	
25.	Mn	0.08	± 10%			73.	Ta	na			
26.	Fe	5.48	± 5%			74.	W			1	
27.	Co			50		75.	Re	na			
28.	Ni			50	± 50%	76.	Os				
29.	Cu			100	± 50%	77.	Ir				
30.	Zn			40	± 50%	78.	Pt				
31.	Ga			10	± 50%	79.	Au				
32.	Ge	na				80.	Hg				
33.	As			11		81.	Tl			0.3	
34.	Se			1		82.	Pb			3	
35.	Br			65		83.	Bi				
37.	Rb			19		84.	Po				
38.	Sr			250	± 50%	85.	At				
39.	Y			8	± 50%	86.	Rn				
40.	Zr			100	± 50%	87.	Fr				
41.	Nb			4		88.	Ra				
42.	Mo			4		89.	Ac				
43.	Tc					90.	Th			1	
44.	Ru			< 0.05		91.	Pa				
45.	Rh	na				92.	U			2	
46.	Pd			< 0.05		93.	Np				
47.	Ag			0.1		94.	Pu				
48.	Cd			< 0.05		95.	Am				
49.	In			< 0.05		96.	Cm				
*CO_2		4.99	± 5%			Free H_2O		16.96	± 5%		
Fe^{+2}/Fe^{+3}		1.27	± 5%			Bound H_2O		4.84	± 5%		

Method of Analysis:
*CO_2 from carbonate
** Expressed as a percent of the concentration
na - not analyzed

Analytical Lab. _____
Lab. Sample No. _____
Date: _____
Signed: _____

RL-3635

ANALYTICAL REPORT

Material: Slightly weathered lapelli tuff

LRL Sample No. 1 M 1144

17-CH-14 496.2-497.4' and 500.5-501.2'

Z		Weight %	±		Weight PPM	±	Z		Weight %	±		Weight PPM	±
1.	H	na	±	**		±	50.	Sn		±	0.1		±
2.	He	na	±			±	51.	Sb		±	< 0.05		±
3.	Li		±		17	± 10%	52.	Te		±			±
4.	Be	na	±			±	53.	I		±	0.2		±
5.	B		±		5	±	55.	Cs		±	0.5		±
6.	C	na	±			±	56.	Ba		±	560		±
7.	N	na	±			±	57.	La		±	20		±
8.	O	na	±			±	58.	Ce		±	45		±
9.	F	na	±			±	59.	Pr		±	5		±
11.	Na	1.8	±	5%		±	60.	Nd		±	20		±
12.	Mg	3.66	±	2%		±	61.	Pm		±			±
13.	Al	8.23	±	2%		±	62.	Sm		±	5		±
14.	Si	24.33	±	2%		±	63.	Eu		±	0.7		±
15.	P	0.082	±	5%		±	64.	Gd		±	3		±
16.	S	0.019	±	5%		±	65.	Tb		±	0.5		±
17.	Cl	na	±			±	66.	Dy		±	4		±
19.	K	0.95	±	5%		±	67.	Ho		±	0.5		±
20.	Ca	6.00	±	2%		±	68.	Er		±	1.5		±
21.	Sc	na	±			±	69.	Tm	na	±			±
22.	Ti	0.76	±	5%		±	70.	Yb		±	1		±
23.	V		±		500	±	71.	Lu		±	0.2		±
24.	Cr		±		50	± 50%	72.	Hf		±	2.5		±
25.	Mn	0.10	±	10%		±	73.	Ta	na	±			±
26.	Fe	6.02	±	5%		±	74.	W		±	3		±
27.	Co		±		20	±	75.	Re	na	±			±
28.	Ni		±		20	±	76.	Os		±			±
29.	Cu		±		100	±	77.	Ir		±			±
30.	Zn		±		115	±	78.	Pt		±			±
31.	Ga	na	±			±	79.	Au		±			±
32.	Ge	na	±			±	80.	Hg		±			±
33.	As		±		0.2	±	81.	Tl		±	0.05		±
34.	Se		±		0.4	±	82.	Pb		±	2		±
35.	Br		±		2	±	83.	Bi		±			±
37.	Rb		±		6	±	84.	Po		±			±
38.	Sr		±		770	±	85.	At		±			±
39.	Y		±		35	±	86.	Rn		±			±
40.	Zr		±		100	±	87.	Fr		±			±
41.	Nb		±		0.2	±	88.	Ra		±			±
42.	Mo		±		0.8	±	89.	Ac		±			±
43.	Tc		±			±	90.	Th		±	2		±
44.	Ru		±			±	91.	Pa		±	0.7		±
45.	Rh	na	±			±	92.	U		±			±
46.	Pd		±		0.05	±	93.	Np		±			±
47.	Ag		±		< 0.05	±	94.	Pu		±			±
48.	Cd		±		< 0.05	±	95.	Am		±			±
49.	In		±		0.5	±	96.	Cm		±			±
	*CO_2	0.15	±	5%		±				±			±
Fe^{+2}/Fe^{+3}		0.40	±	5%		±				±			±

Method of Analysis:
*CO_2 from carbonate

** Expressed as a percent of the concentration

na - not analyzed

Analytical Lab.

Lab. Sample No.

Date:

Signed:

RL-3635

ANALYTICAL REPORT

Material Fresh tuff — LRL Sample No. 1 M 1117

17-CH 14 576.5-578.2'

Z		Weight %	±	**	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na					50.	Sn			0.05	
2.	He	na					51.	Sb			< 0.05	
3.	Li				21	± 5%	52.	Te				
4.	Be	na					53.	I			0.05	
5.	B				7		55.	Cs			0.5	
6.	C	na					56.	Ba			320	
7.	N	na					57.	La			24	
8.	O	na					58.	Ce			40	
9.	F	na					59.	Pr			5	
11.	Na	1.6	± 5%				60.	Nd			17	
12.	Mg	2.58	± 2%				61.	Pm				
13.	Al	8.03	± 2%				62.	Sm			4	
14.	Si	25.14	± 2%				63.	Eu			0.6	
15.	P	0.080	± 10%				64.	Gd			3	
16.	S	0.018	± 5%				65.	Tb			0.5	
17.	Cl	na					66.	Dy			3	
19.	K	1.2	± 5%				67.	Ho			0.6	
20.	Ca	6.06	± 2%				68.	Er			1.5	
21.	Sc	na					69.	Tm	na			
22.	Ti	0.59	± 5%				70.	Yb			1	
23.	V				460		71.	Lu			< 0.05	
24.	Cr				20	± 50%	72.	Hf			2	
25.	Mn	0.12	± 10%				73.	Ta	na			
26.	Fe	5.06	± 5%				74.	W				
27.	Co				32		75.	Re	na			
28.	Ni				16		76.	Os				
29.	Cu				51		77.	Ir				
30.	Zn				44		78.	Pt				
31.	Ga	na					79.	Au				
32.	Ge	na					80.	Hg				
33.	As				0.2		81.	Tl				
34.	Se				0.5		82.	Pb			1.5	
35.	Br				1		83.	Bi				
37.	Rb				8		84.	Po				
38.	Sr				380		85.	At				
39.	Y				32		86.	Rn				
40.	Zr				130		87.	Fr				
41.	Nb				0.6		88.	Ra				
42.	Mo				0.5		89.	Ac				
43.	Tc						90.	Th			1	
44.	Ru				2		91.	Pa				
45.	Rh	na					92.	U			0.3	
46.	Pd				0.1		93.	Np				
47.	Ag				0.05		94.	Pu				
48.	Cd						95.	Am				
49.	In				< 0.05		96.	Cm				
	*CO_2	2.52	± 5%									
Fe^{+2}/Fe^{+3}		0.30	± 5%									

Method of Analysis:
*CO_2 from carbonate
** Expressed as a percent of the concentration
na - not analyzed

Analytical Lab. _____
Lab. Sample No. _____
Date: _____
Signed: _____

RL-3635

ANALYTICAL REPORT

Material: Interbedded tuffaceous agglomerate and sandstone — LRL Sample No. 1 M 1131

17-CH-14 601.4-603.9'

Z		Weight %	±	**	Weight PPM	±		Z		Weight %	±	Weight PPM	±
1.	H	na						50.	Sn			0.2	
2.	He	na						51.	Sb			0.1	
3.	Li				12	±	10%	52.	Te				
4.	Be	na						53.	I				
5.	B				5			55.	Cs			0.6	
6.	C	na						56.	Ba			1300	
7.	N	na						57.	La			55	
8.	O	na						58.	Ce			115	
9.	F	na						59.	Pr			8	
11.	Na	1.8	±	5%				60.	Nd			40	
12.	Mg	2.34	±	2%				61.	Pm				
13.	Al	8.48	±	2%				62.	Sm			10	
14.	Si	24.60	±	2%				63.	Eu			1.5	
15.	P	0.116	±	5%				64.	Gd			8	
16.	S	0.048	±	5%				65.	Tb			0.9	
17.	Cl	na						66.	Dy			5	
19.	K	2.0	±	5%				67.	Ho			0.9	
20.	Ca	5.02	±	2%				68.	Er			4	
21.	Sc	na						69.	Tm	na			
22.	Ti	0.96	±	5%				70.	Yb			4	
23.	V				500			71.	Lu			2	
24.	Cr				20	±	50%	72.	Hf			5	
25.	Mn	0.06	±	20%				73.	Ta	na			
26.	Fe	5.35	±	5%				74.	W				
27.	Co				60			75.	Re	na			
28.	Ni				40			76.	Os				
29.	Cu				220			77.	Ir				
30.	Zn				240			78.	Pt				
31.	Ga	na						79.	Au				
32.	Ge	na						80.	Hg				
33.	As				1			81.	Tl				
34.	Se				0.5			82.	Pb			3	
35.	Br				4			83.	Bi				
37.	Rb				25			84.	Po				
38.	Sr				880			85.	At				
39.	Y				70			86.	Rn				
40.	Zr				255			87.	Fr				
41.	Nb				2			88.	Ra				
42.	Mo							89.	Ac				
43.	Tc							90.	Th			2	
44.	Ru				5			91.	Pa				
45.	Rh	na						92.	U			0.4	
46.	Pd							93.	Np				
47.	Ag							94.	Pu				
48.	Cd							95.	Am				
49.	In				0.2			96.	Cm				
*CO_2		1.69	±	5%									
Fe^{+2}/Fe^{+3}		0.28	±	5%									

Method of Analysis:
*CO_2 from carbonate
** Expressed as a percent of the concentration
na - not analyzed

Analytical Lab.
Lab. Sample No.
Date:
Signed:

RL-3635

ANALYTICAL REPORT

Material Agglomerate — LRL Sample No. 131

17-CH-14 715'

Z	Weight %	±**	Weight PPM	±	Z	Weight %	±	Weight PPM	±
1. H	na				50. Sn			< 0.05	
2. He	na				51. Sb			0.05	
3. Li			14	±10%	52. Te			< 0.05	
4. Be			0.5		53. I				
5. B			5		55. Cs			0.2	
6. C	na				56. Ba			400	±50%
7. N	na				57. La			5	±50%
8. O	na				58. Ce			16	
9. F	na				59. Pr			3	
11. Na	2.6	± 5%			60. Nd			10	
12. Mg	3.07	± 2%			61. Pm				
13. Al	9.32	± 2%			62. Sm			4	
14. Si	25.21	± 2%			63. Eu			0.7	
15. P	0.044	± 5%			64. Gd			4	
16. S	0.009	±10%			65. Tb			0.4	
17. Cl	na				66. Dy			3	
19. K	1.1	± 5%			67. Ho			0.3	
20. Ca	5.47	± 2%			68. Er			1	
21. Sc			30	±50%	69. Tm	na			
22. Ti	0.59	± 5%			70. Yb			2	
23. V			250	±50%	71. Lu			< 0.05	
24. Cr			80	±50%	72. Hf			1	
25. Mn	0.05	±20%			73. Ta	na			
26. Fe	5.19	± 5%			74. W				
27. Co			11		75. Re	na			
28. Ni			25	±50%	76. Os				
29. Cu			100	±50%	77. Ir				
30. Zn			40	±50%	78. Pt				
31. Ga			20	±50%	79. Au				
32. Ge	na				80. Hg				
33. As			0.3		81. Tl			0.2	
34. Se			0.6		82. Pb			2	
35. Br			1		83. Bi				
37. Rb			21		84. Po				
38. Sr			300	±50%	85. At				
39. Y			10	±50%	86. Rn				
40. Zr			100	±50%	87. Fr				
41. Nb			0.2		88. Ra				
42. Mo			0.7		89. Ac				
43. Tc					90. Th			0.5	
44. Ru			7		91. Pa				
45. Rh	na				92. U				
46. Pd			0.1		93. Np				
47. Ag			0.1		94. Pu				
48. Cd			< 0.05		95. Am				
49. In			< 0.05		96. Cm				
*CO_2	0.18	± 5%							
Fe^{+2}/Fe^{+3}	0.48	± 5%							

Method of Analysis:

* CO_2 from carbonate

**Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

RL-3635

ANALYTICAL REPORT

Material Fresh Calcareous tuff
17-CH-15 272.5-274.0'
275.2-275.9'
278.9-279.2'

LRL Sample No. 1 M 1461

Z		Weight %	± **	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na				50.	Sn				
2.	He	na				51.	Sb				
3.	Li			21	± 5%	52.	Te				
4.	Be	na				53.	I			2	
5.	B			50	± 50%	55.	Cs				
6.	C	na				56.	Ba			650	
7.	N	na				57.	La			6	
8.	O	na				58.	Ce			8	
9.	F	na				59.	Pr			1.5	
11.	Na	2.2	± 5%			60.	Nd			7	
12.	Mg	1.44	± 2%			61.	Pm				
13.	Al	6.88	± 2%			62.	Sm			2	
14.	Si	20.03	± 2%			63.	Eu			0.4	
15.	P	0.005	± 20%			64.	Gd			1	
16.	S	0.51	± 5%			65.	Tb			0.3	
17.	Cl	na				66.	Dy			1	
19.	K	1.5	± 5%			67.	Ho			1	
20.	Ca	10.09	± 2%			68.	Er			2	
21.	Sc	na				69.	Tm	na			
22.	Ti	0.48	± 5%			70.	Yb				
23.	V			300		71.	Lu				
24.	Cr			90	± 50%	72.	Hf			2	
25.	Mn	0.02	± 20%			73.	Ta	na			
26.	Fe	4.83	± 5%			74.	W				
27.	Co			20		75.	Re	na			
28.	Ni			65		76.	Os				
29.	Cu			40		77.	Ir				
30.	Zn			85		78.	Pt				
31.	Ga	na				79.	Au				
32.	Ge	na				80.	Hg				
33.	As			8		81.	Tl				
34.	Se			9		82.	Pb			1.5	
35.	Br			8		83.	Bi				
37.	Rb			7		84.	Po				
38.	Sr			820		85.	At				
39.	Y			18		86.	Rn				
40.	Zr			18		87.	Fr				
41.	Nb			0.3		88.	Ra				
42.	Mo					89.	Ac				
43.	Tc					90.	Th				
44.	Ru			5		91.	Pa				
45.	Rh	na				92.	U			0.8	
46.	Pd					93.	Np				
47.	Ag			0.4		94.	Pu				
48.	Cd					95.	Am				
49.	In					96.	Cm				
*CO_2		9.56	± 5%								
Fe^{+2}/Fe^{+3}		0.51	± 5%								

Method of Analysis:
*CO_2 from carbonate
** Expressed as a percent of the concentration
na - not analyzed

Analytical Lab. _____
Lab. Sample No. _____
Date: _____
Signed: _____

RL-3635

ANALYTICAL REPORT

Material: Fresh calcareous tuffaceous sandstone

LRL Sample No. 1 M 1379

17-CH-15 416.8-417.8' 418.9-420.2'

Z		Weight %	± **	Weight PPM	±
1.	H	na			
2.	He	na			
3.	Li			28	± 5%
4.	Be	na			
5.	B			50	± 50%
6.	C	na			
7.	N	na			
8.	O	na			
9.	F	na			
11.	Na	3.4	± 5%		
12.	Mg	1.89	± 2%		
13.	Al	7.82	± 2%		
14.	Si	23.39	± 2%		
15.	P	0.007	±20%		
16.	S	0.46	± 5%		
17.	Cl	na			
19.	K	0.83	± 5%		
20.	Ca	6.15	± 2%		
21.	Sc	na			
22.	Ti	0.63	± 5%		
23.	V			350	
24.	Cr			50	± 50%
25.	Mn	0.07	±20%		
26.	Fe	4.92	± 5%		
27.	Co			16	
28.	Ni			34	
29.	Cu			51	
30.	Zn			70	
31.	Ga	na			
32.	Ge	na			
33.	As			2.5	
34.	Se			0.3	
35.	Br			2	
37.	Rb			4	
38.	Sr			640	
39.	Y			14	
40.	Zr			22	
41.	Nb			< 0.05	
42.	Mo				
43.	Tc				
44.	Ru				
45.	Rh	na			
46.	Pd				
47.	Ag			< 0.05	
48.	Cd				
49.	In			< 0.05	
	*CO_2	4.88	± 5%		
	Fe^{+2}/Fe^{2+3}	0.41	± 5%		

Z		Weight %	±	Weight PPM	±
50.	Sn				
51.	Sb			< 0.05	
52.	Te				
53.	I			1	
55.	Cs			0.3	
56.	Ba			450	
57.	La			5	
58.	Ce			7	
59.	Pr			3	
60.	Nd			4	
61.	Pm				
62.	Sm			1	
63.	Eu			0.3	
64.	Gd			1	
65.	Tb			0.3	
66.	Dy			1.5	
67.	Ho			0.3	
68.	Er			0.7	
69.	Tm	na			
70.	Yb			0.5	
71.	Lu				
72.	Hf			0.8	
73.	Ta	na			
74.	W				
75.	Re	na			
76.	Os				
77.	Ir				
78.	Pt				
79.	Au				
80.	Hg				
81.	Tl				
82.	Pb			1	
83.	Bi				
84.	Po				
85.	At				
86.	Rn				
87.	Fr				
88.	Ra				
89.	Ac				
90.	Th			< 0.05	
91.	Pa				
92.	U			0.4	
93.	Np				
94.	Pu				
95.	Am				
96.	Cm				

Method of Analysis:
* CO_2 from carbonate
** Expressed as a percent of the concentration
na - not analyzed

Analytical Lab. _____
Lab. Sample No. _____
Date: _____
Signed: _____

RL-3635

ANALYTICAL REPORT

Material Fresh Fossiliferous shale
17-CH-17 113'

LRL Sample No. 222/159

Z	Weight %	±	Weight PPM	±	Z	Weight %	±	Weight PPM	±
1. H	na	±**		±	50. Sn		±	0.05	±
2. He	na	±		±	51. Sb		±	0.05	±
3. Li		±	88	± 5%	52. Te		±		±
4. Be	na	±		±	53. I		±	1	±
5. B		±	60	± 50%	55. Cs		±	1	±
6. C	na	±		±	56. Ba		±	740	±
7. N	na	±		±	57. La		±	4	±
8. O	na	±		±	58. Ce		±	9	±
9. F	na	±		±	59. Pr		±	1	±
11. Na	1.5	± 5%		±	60. Nd		±	2.5	±
12. Mg	2.13	± 2%		±	61. Pm		±		±
13. Al	8.74	± 2%		±	62. Sm		±	2	±
14. Si	25.58	± 2%		±	63. Eu		±	0.2	±
15. P	0.008	± 10%		±	64. Gd		±		±
16. S	1.47	± 5%		±	65. Tb		±		±
17. Cl	na	±		±	66. Dy		±		±
19. K	1.1	± 5%		±	67. Ho		±		±
20. Ca	2.56	± 2%		±	68. Er		±		±
21. Sc	na	±		±	69. Tm	na	±		±
22. Ti	0.74	± 5%		±	70. Yb		±	0.7	±
23. V		±	270	±	71. Lu		±		±
24. Cr		±	120	± 50%	72. Hf		±		±
25. Mn	0.04	± 20%		±	73. Ta	na	±		±
26. Fe	5.72	± 5%		±	74. W		±		±
27. Co		±	6.4	±	75. Re	na	±		±
28. Ni		±	30	±	76. Os		±	0.5	±
29. Cu		±	35	±	77. Ir		±		±
30. Zn		±	35	±	78. Pt		±		±
31. Ga	na	±		±	79. Au		±		±
32. Ge	na	±		±	80. Hg		±		±
33. As		±	0.3	±	81. Tl		±		±
34. Se		±	0.05	±	82. Pb		±	1	±
35. Br		±	3	±	83. Bi		±		±
37. Rb		±	10	±	84. Po		±		±
38. Sr		±	400	±	85. At		±		±
39. Y		±	18	±	86. Rn		±		±
40. Zr		±	120	±	87. Fr		±		±
41. Nb		±	0.8	±	88. Ra		±		±
42. Mo		±		±	89. Ac		±		±
43. Tc		±		±	90. Th		±	1.5	±
44. Ru		±		±	91. Pa		±		±
45. Rh	na	±		±	92. U		±	0.4	±
46. Pd		±		±	93. Np		±		±
47. Ag		±	0.05	±	94. Pu		±		±
48. Cd		±		±	95. Am		±		±
49. In		±		±	96. Cm		±		±
*CO_2	2.22%	± 5%		±			±		±
Fe^{+2}/Fe^{+3}	1.22	± 5%		±			±		±

Method of Analysis:
*CO_2 From carbonate
**Expressed as a percent of the concentration
na - not analyzed

Analytical Lab. _____
Lab. Sample No. _____
Date: _____
Signed: _____

RL-3635

ANALYTICAL REPORT

Material: Altered porphyrites basalt
17-CH-21 150.5-154.5'

LRL Sample No. 1M 1405

Z	Weight %	±	Weight PPM	±	Z	Weight %	±	Weight PPM	±
1. H	na				50. Sn			< 0.05	
2. He	na				51. Sb			< 0.05	
3. Li			24		52. Te				
4. Be			0.5		53. I			0.1	
5. B			< 5		55. Cs			0.8	
6. C	na				56. Ba			400	± 50%
7. N	na				57. La			4	
8. O	na				58. Ce			8	
9. F	na				59. Pr			1	
11. Na	2.5	± 5%			60. Nd			3	
12. Mg	3.73	± 2%			61. Pm				
13. Al	9.08	± 2%			62. Sm			1	
14. Si	25.54	± 2%			63. Eu			0.3	
15. P	0.005	± 20%			64. Gd			1	
16. S	0.012	± 10%			65. Tb			0.2	
17. Cl	na				66. Dy			1	
19. K	0.82	± 5%			67. Ho			0.4	
20. Ca	5.33	± 2%			68. Er			0.5	
21. Sc			25	± 50%	69. Tm	na			
22. Ti	0.55	± 5%			70. Yb			4	
23. V			200	± 50%	71. Lu			< 0.05	
24. Cr			120	± 50%	72. Hf				
25. Mn	0.09	± 10%			73. Ta	na			
26. Fe	5.37	± 5%			74. W				
27. Co			16		75. Re	na			
28. Ni			35	± 50%	76. Os				
29. Cu			120	± 50%	77. Ir				
30. Zn			40	± 50%	78. Pt				
31. Ga			20	± 50%	79. Au				
32. Ge	na				80. Hg				
33. As			< 0.05		81. Tl			0.1	
34. Se			2		82. Pb			2	
35. Br			0.6		83. Bi				
37. Rb			5		84. Po				
38. Sr			300	± 50%	85. At				
39. Y			12	± 50%	86. Rn				
40. Zr			75	± 50%	87. Fr				
41. Nb			0.2		88. Ra				
42. Mo					89. Ac				
43. Tc					90. Th				
44. Ru					91. Pa				
45. Rh	na				92. U				
46. Pd					93. Np				
47. Ag			< 0.05		94. Pu				
48. Cd					95. Am				
49. In			< 0.05		96. Cm				
*CO_2	0.25	± 5%							
Fe^{+2}/Fe^{+3}	0.58	± 5%							

Method of Analysis:
*CO_2 from carbonate
**Expressed as a percent of the concentration.
na - not analyzed

Analytical Lab. _____
Lab. Sample No. _____
Date: _____
Signed: _____

RL-3635

ANALYTICAL REPORT

Material Tuffaceous siltstone
17-CH-22 500'

LRL Sample No. 124

Z		Weight %	±	Weight PPM	±	Z		Weight %	±	Weight PPM	±
1.	H	na	±**		±	50.	Sn		±	< 0.05	±
2.	He	na	±		±	51.	Sb		±	< 0.05	±
3.	Li		±	6	±10%	52.	Te		±		±
4.	Be	na	±		±	53.	I		±		±
5.	B		±	5	±	55.	Cs		±	< 0.05	±
6.	C	na	±		±	56.	Ba		±	145	±
7.	N	na	±		±	57.	La		±	4	±
8.	O	na	±		±	58.	Ce		±	8	±
9.	F	na	±		±	59.	Pr		±	2	±
11.	Na	3.8	± 5%		±	60.	Nd		±	7	±
12.	Mg	2.35	± 2%		±	61.	Pm		±		±
13.	Al	8.52	± 2%		±	62.	Sm		±	3	±
14.	Si	25.89	± 2%		±	63.	Eu		±	0.4	±
15.	P	0.052	± 5%		±	64.	Gd		±	2	±
16.	S	0.018	± 5%		±	65.	Tb		±		±
17.	Cl	na	±		±	66.	Dy		±	2	±
19.	K	0.81	± 5%		±	67.	Ho		±	0.4	±
20.	Ca	4.46	± 2%		±	68.	Er		±	1	±
21.	Sc	na	±		±	69.	Tm	na	±		±
22.	Ti	0.89	± 5%		±	70.	Yb		±	1	±
23.	V		±	230	±	71.	Lu		±	< 0.05	±
24.	Cr		±	< 10	±	72.	Hf		±	1.5	±
25.	Mn	0.10	±10%		±	73.	Ta	na	±		±
26.	Fe	7.33	± 5%		±	74.	W		±		±
27.	Co		±	12	±	75.	Re	na	±		±
28.	Ni		±	10	±	76.	Os		±		±
29.	Cu		±	65	±	77.	Ir		±		±
30.	Zn		±	40	±	78.	Pt		±		±
31.	Ga	na	±		±	79.	Au		±		±
32.	Ge	na	±		±	80.	Hg		±		±
33.	As		±	0.1	±	81.	Tl		±		±
34.	Se		±	0.3	±	82.	Pb		±	0.5	±
35.	Br		±	0.5	±	83.	Bi		±		±
37.	Rb		±	0.5	±	84.	Po		±		±
38.	Sr		±	105	±	85.	At		±		±
39.	Y		±	20	±	86.	Rn		±		±
40.	Zr		±	29	±	87.	Fr		±		±
41.	Nb		±	0.2	±	88.	Ra		±		±
42.	Mo		±		±	89.	Ac		±		±
43.	Tc		±		±	90.	Th		±	0.1	±
44.	Ru		±	6	±	91.	Pa		±		±
45.	Rh	na	±		±	92.	U		±		±
46.	Pd		±	0.05	±	93.	Np		±		±
47.	Ag		±		±	94.	Pu		±		±
48.	Cd		±		±	95.	Am		±		±
49.	In		±	< 0.05	±	96.	Cm		±		±
* CO_2		0.07	±10%		±	Free H_2O		1.48	± 5%		±
Fe^{+2}/Fe^{+3}		1.54	± 5%		±	Bound H_2O		2.18	± 5%		±

Method of Analysis:
*CO_2 from carbonate
** Expressed as a percent of the concentration
na - not analyzed

Analytical Lab. _____
Lab. Sample No. _____
Date: _____
Signed: _____

RL-3635

ANALYTICAL REPORT

Material Fresh altered tuff
17-CH-22 1443'

LRL Sample No. 132

Z	Weight %	± **	Weight PPM	±	Z	Weight %	±	Weight PPM	±
1. H	na				50. Sn			< 0.05	
2. He	na				51. Sb			0.1	
3. Li			13	± 10%	52. Te			< 0.05	
4. Be	na				53. I				
5. B			10	± 50%	55. Cs			0.1	
6. C	na				56. Ba			50	
7. N	na				57. La			1	
8. O	na				58. Ce			3	
9. F	na				59. Pr			0.5	
11. Na	0.80	± 5%			60. Nd			3	
12. Mg	6.01	± 2%			61. Pm				
13. Al	6.90	± 2%			62. Sm			2	
14. Si	23.00	± 2%			63. Eu			0.4	
15. P	0.025	± 5%			64. Gd			1	
16. S	0.012	± 10%			65. Tb			0.3	
17. Cl	na				66. Dy			1	
19. K	0.41	± 5%			67. Ho			0.3	
20. Ca	5.76	± 2%			68. Er			1	
21. Sc	na				69. Tm	na			
22. Ti	0.82	± 5%			70. Yb			1	
23. V			310		71. Lu				
24. Cr			400	± 50%	72. Hf			0.3	
25. Mn	0.04	± 20%			73. Ta	na			
26. Fe	6.49	± 5%			74. W				
27. Co			12		75. Re	na			
28. Ni			70		76. Os				
29. Cu			24		77. Ir				
30. Zn			37		78. Pt				
31. Ga	na				79. Au				
32. Ge	na				80. Hg				
33. As			0.4		81. Tl				
34. Se			1		82. Pb			0.4	
35. Br			1		83. Bi				
37. Rb			0.7		84. Po				
38. Sr			420		85. At				
39. Y			18		86. Rn				
40. Zr			26		87. Fr				
41. Nb			0.2		88. Ra				
42. Mo			2		89. Ac				
43. Tc					90. Th				
44. Ru			3		91. Pa				
45. Rh	na				92. U				
46. Pd			< 0.05		93. Np				
47. Ag			0.1		94. Pu				
48. Cd					95. Am				
49. In			< 0.05		96. Cm				
*CO_2	0.47	± 5%			Free H_2O	7.74	± 5%		
Fe^{+2}/Fe^{2+3}	0.90	± 5%			Bound H_2O	6.86	± 5%		

Method of Analysis:

*CO_2 from carbonate

** Expressed as a percent of the concentration

na - not analyzed

Analytical Lab. _____

Lab. Sample No. _____

Date: _____

Signed: _____

RL-3635

Appendix B

CHEMICAL ANALYSIS OF CORE SAMPLES BY
CORPS OF ENGINEERS

These data are reproduced from an IOCS Memorandum on the subsurface geology of Route 17.*

*See Ref. 1.

PART IV

CHEMICAL TESTS

Rock type	Boring number	Depth (feet)	Lab number	Sample description
1	17-CH-4	113	222/183	Calcareous shale with silty interbeds
1	17-CH-4	383	1M1310	Calcareous shale
1	17-CH-13	321	222/64	Moderately weathered calcareous shale
1	17-CH-13	789	1M1316	Fresh shale
1	17-CH-17	113	222/159	Fresh fossiliferous shale
2	17-CH-5	400	1M1311	Bedded tuff
2	17-CH-7	675	1M1312	Calcareous tuff
2	17-CH-8	261-263	1M1177	Tuffaceous fossiliferous limestone
2	17-CH-5	257-258	1M1006	Fresh calcareous tuff
3	17-CH-5	197-198	1M1200	Slightly weathered silty and tuffaceous limestone
3	17-CH-10	364-365	1M1213 & 1M1215	Fresh tuffaceous limestone
3	17-CH-10	500	1M1314	Fresh tuffaceous limestone
4	17-CH-9	460-462	1M1043	Fresh tuffaceous limestone
4	17-CH-9	680	1M1313	Slightly weathered siliceous shale
4	17-CH-13	207-208	1M1248	Fresh tuffaceous limestone
5	17-CH-12	288-291	1M1073	Agglomerate
5	17-CH-12	383-384	1M1328	Agglomerate with tuffaceous matrix

Chemical tests - continued

Rock type	Boring number	Depth (feet)	Lab number	Sample description
6	17-CH-12	117-118	1M1262 & 1M1264	Fresh tuffaceous sandstone
6	17-CH-12	180-182	1M1281	Fresh tuffaceous siltstone
6	17-CH-12	970	1M1315	Fresh tuffaceous sandstone
6	17-CH-15	418-419	1M1379 & 1M1381	Fresh calcareous tuffaceous sandstone
7	17-CH-7	104-107	1M1089	Slightly weathered and altered diabase
7	17-CH-7	652-654	1M1093	Slightly weathered altered diabase
8	17-CH-11	85-86	1M1411	Fresh to slightly weathered diabase
8	17-CH-11	497-499	1M1419	Porphyritic amygdaloidal altered and slightly weathered basalt
8	17-CH-11	897-899	1M1113	Altered and weathered porphyritic basalt
8	17-CH-21	151-155	1M1405	Altered porphyritic basalt
9	17-CH-15	276-277	1M1461 & 1M1465	Fresh calcareous tuff
10	17-CH-11	926-929	1M1475	Fresh altered tuff
10	17-CH-14	577-578	1M1117	Fresh tuff
10	17-CH-14	600-604	1M1131	Interbedded tuffaceous agglomerate and sandstone
11	17-CH-14	489-491	1M1147 & 1M1144	Slightly weathered lapilli tuff
12	17-CH-22	1143	1M1317	Fresh altered tuff

U. S. ARMY ENGINEER DIVISION LABORATORY, SOUTH ATLANTIC
CORPS OF ENGINEERS
MARIETTA, GEORGIA

DISTRICT: Jacksonville
PROJECT: Route 17, Interoceanic Canal Study
CONTRACT NO.:

GENERAL TEST REPORT

(ROCK CORES)

DATE REPORTED: 5 July 1968
WORK ORDER NO.: 4965
REQN. NO.: 08-123-ENG-108-68C
BASE UNIT COST:
DATE SAMPLE RECEIVED:
LAB NO.: See below

DESCRIPTION: See below
SOURCE: See below
FOR USE AS:
TESTED FOR: Chemical Analysis (% by wt.)

☐ MEETS SPECIFICATIONS ☐ FAILS SPECIFICATIONS (See below)

Lab No.	222/183		1M1310		222/64		1M1316	
Core Hole	17-CH-4		17-CH-4		17-CH-13		17-CH-13	
Depth (ft.)	113		383		321		789	
Rock Type	1*		1**		1***		1****	
Run	A	B	A	B	A	B	A	B
Silicon as SiO_2	47.30	47.72	54.30	54.36	44.75	45.20	48.10	48.48
Aluminum as Al_2O_3	16.37	16.39	15.45	15.66	15.49	15.21	16.72	16.62
Iron as Fe_2O_3	6.41	6.33	5.56	5.40	7.37	7.45	8.10	8.02
Manganese as MnO	0.05	0.05	0.03	0.05	0.05	0.05	0.08	0.10
Titanium as TiO_2	0.70	0.59	0.37	0.39	0.69	0.70	0.05	0.05
Phosphorous as P_2O_5	0.24	0.18	0.21	0.20	0.16	0.14	0.25	0.23
Calcium as CaO	5.52	5.68	4.74	4.82	6.16	6.12	4.50	4.58
Magnesium as MgO	2.02	1.98	2.21	2.02	3.63	3.83	3.40	3.04
Sodium as Na_2O	0.98	1.08	0.78	0.90	1.48	1.54	1.30	1.30
Potassium as K_2O	0.70	0.78	0.98	0.68	1.48	1.48	0.85	1.00
Water, Crystallization	8.95	7.70	5.46	5.02	7.17	7.40	6.72	7.03
Water, Hygroscopic	5.48	5.67	3.88	3.92	4.97	4.98	4.85	4.70
Carbonates as CO_2	3.77	3.98	2.57	2.47	5.00	5.02	3.38	3.48
Ignition Loss (850°C)	16.88	17.41	11.14	11.29	16.37	16.33	13.81	14.20

REMARKS: *Calcareous shale with silty interbeds.
**Calcareous shale.
***Moderately weathered calcareous shale.
****Fresh shale.

REPORTED BY: ☐ PHONE ☐ WIRE
DATE:
TESTED BY: DW
CHECKED BY: DW
SAMPLED BY:

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CORPS OF ENGINEERS
MARIETTA, GEORGIA

DISTRICT: Jacksonville
PROJECT: Route 17, Interoceanic Canal Study
CONTRACT NO.:

GENERAL TEST REPORT

(ROCK CORES)

DATE REPORTED: 5 July 1968
WORK ORDER NO.: 4965
DESCRIPTION: See below
REQN. NO.: 08-123-ENG-108-680
SOURCE: See below
BASE UNIT COST:
FOR USE AS:
DATE SAMPLE RECEIVED:
TESTED FOR: Chemical Analysis (% by wt.)
LAB NO.: See below

☐ MEETS SPECIFICATIONS ☐ FAILS SPECIFICATIONS (See below)

Lab No.	222/159	
Core Hole	17-CH-17	
Depth (ft.)	113	
Rock Type	1*	
Run	A	B
Silicon as SiO_2	52.38	52.08
Aluminum as Al_2O_3	15.96	15.76
Iron as Fe_2O_3	7.93	7.93
Manganese as MnO	0.08	0.07
Titanium as TiO_2	0.66	0.75
Phosphorous as P_2O_5	0.13	0.11
Calcium as CaO	3.32	3.28
Magnesium as MgO	3.96	3.93
Sodium as Na_2O	1.68	1.44
Potassium as K_2O	1.22	1.08
Water, Crystallization	6.20	6.41
Water, Hygroscopic	3.87	3.87
Carbonates as CO_2	1.75	1.96
Ignition Loss (850°C)	11.81	11.93

REMARKS: *Fresh fossiliferous shale.

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	PROJECT Route 17, Interoceanic Canal Study
	CONTRACT NO.
GENERAL TEST REPORT (ROCK CORES)	DATE REPORTED 5 July 1968
	WORK ORDER NO. 4965
DESCRIPTION See below	REQN. NO. 08-123-ENG-108-68C
SOURCE See below	BASE UNIT COST
FOR USE AS:	DATE SAMPLE RECEIVED
TESTED FOR: Chemical Analysis (% by wt.)	LAB NO. See below

☐ MEETS SPECIFICATIONS ☐ FAILS SPECIFICATIONS (See below)

Lab No.	1M1311		1M1312		1M1177		1M1006	
Core Hole	17-CH-5		17-CH-7		17-CH-8		17-CH-5	
Depth (ft.)	400		675		261-263		257-258	
Rock Type	2*		2**		2***		2****	
Run	A	B	A	B	A	B	A	B
Silicon as SiO_2	53.32	53.48	59.60	59.76	23.18	23.22	64.50	64.70
Aluminum as Al_2O_3	13.83	14.04	4.59	4.74	5.93	6.08	10.13	10.02
Iron as Fe_2O_3	5.73	5.52	3.44	3.44	5.45	5.41	2.00	2.04
Manganese as MnO	0.05	0.06	0.04	0.03	0.00	0.00	0.10	0.08
Titanium as TiO_2	0.38	0.38	0.29	0.26	0.54	0.53	0.21	0.22
Phosphorous as P_2O_5	0.24	0.22	0.09	0.10	0.72	0.56	0.48	0.60
Calcium as CaO	9.62	9.52	15.50	15.48	31.08	31.11	8.64	8.44
Magnesium as MgO	2.44	2.37	1.03	0.91	2.40	2.37	1.01	0.88
Sodium as Na_2O	1.48	1.55	0.45	0.52	0.68	0.64	0.72	0.70
Potassium as K_2O	0.70	0.80	0.05	0.04	0.96	0.92	0.28	0.34
Water, Crystallization	6.19	6.18	3.26	3.06	3.41	3.32	5.60	5.51
Water, Hygroscopic	1.54	1.52	0.28	0.32	2.46	2.46	1.94	1.88
Carbonates as CO_2	4.90	5.12	11.90	11.81	23.31	23.65	5.00	5.20
Ignition Loss (850°C)	10.16	10.43	12.20	12.28	27.40	27.22	11.70	11.98

REMARKS: *Bedded Tuff
**Calcareous Tuff
***Tuffaceous fossiliferous limestone
****Fresh calcareous tuff

REPORTED BY: ☐ PHONE ☐ WIRE	TESTED BY DW	CHECKED BY DW
DATE:	SAMPLED BY	

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MARIETTA, GEORGIA

DISTRICT: Jacksonville
PROJECT: Route 17, Interoceanic Canal Study
CONTRACT NO.:

GENERAL TEST REPORT

(ROCK CORES)

DATE REPORTED: 5 July 1968
WORK ORDER NO.: 4965
DESCRIPTION: See below
REQN. NO.: 08-123-ENG-108-68C
SOURCE: See below
BASE UNIT COST:
FOR USE AS:
DATE SAMPLE RECEIVED:
TESTED FOR: Chemical Analysis (% by wt.)
LAB NO.: See below

☐ MEETS SPECIFICATIONS ☐ FAILS SPECIFICATIONS (See below)

Lab No.	1M1200		1M1213 & 1215		1M1314	
Core Hole	17-CH-5		17-CH-10		17-CH-10	
Depth (ft.)	197-198		364-365		500	
Rock Type	3*		3**		3**	
Run	A	B	A	B	A	B
Silicon as SiO_2	62.10	62.10	43.91	44.58	71.86	71.56
Aluminum as Al_2O_3	9.42	9.39	2.52	2.36	3.06	3.12
Iron as Fe_2O_3	2.32	2.36	0.80	0.80	1.23	1.23
Manganese as MnO	0.00	0.00	0.00	0.00	0.06	0.10
Titanium as TiO_2	0.20	0.17	0.00	0.00	0.09	0.08
Phosphorous as P_2O_5	0.68	0.48	0.00	0.00	0.07	0.05
Calcium as CaO	11.23	11.32	27.17	27.10	10.72	10.76
Magnesium as MgO	1.08	1.27	0.64	0.55	0.83	0.83
Sodium as Na_2O	0.78	0.80	0.42	0.50	0.45	0.40
Potassium as K_2O	0.36	0.42	0.36	0.36	0.32	0.25
Water, Crystallization	3.85	3.91	1.82	1.63	1.95	2.26
Water, Hygroscopic	1.28	1.44	0.10	0.08	0.38	0.38
Carbonates as CO_2	6.97	7.01	20.83	20.54	9.43	9.29
Ignition Loss (850°C)	11.58	11.44	21.77	21.75	10.53	10.83

REMARKS: *Slightly weathered silty and tuffaceous limestone.
**Fresh tuffaceous limestone.

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DATE:

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CHECKED BY: DW
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DISTRICT: Jacksonville
PROJECT: Route 17, Interoceanic Canal Study
CONTRACT NO.:

GENERAL TEST REPORT

(ROCK CORES)

DATE REPORTED: 31 July 1968
WORK ORDER NO.: 4965
REQN. NO.: 08-123-ENG-108-68C
BASE UNIT COST:
DATE SAMPLE RECEIVED:
LAB NO.: See below

DESCRIPTION: See below
SOURCE: See below
FOR USE AS:
TESTED FOR: Chemical Analysis (% by weight)

☐ MEETS SPECIFICATIONS ☐ FAILS SPECIFICATIONS (See below)

Lab. No.	1M1043		1M1313		1M1248	
Core Hole	17-CH-9		17-CH-9		17-CH-13	
Depth (ft.)	460-462		680		207-208	
Rock Type	4*		4**		4***	
Run	A	B	A	B	A	B
Silicon as SiO_2	41.12	40.94	62.44	62.48	38.90	38.88
Aluminum as Al_2O_3	8.81	8.89	9.00	8.90	8.01	8.40
Iron as Fe_2O_3	3.76	3.68	3.68	3.76	3.60	3.68
Manganese as MnO	0.03	0.02	0.04	0.04	0.04	0.04
Titanium as TiO_2	0.38	0.38	0.46	0.46	0.38	0.36
Phosphorus as P_2O_5	0.14	0.15	0.12	0.14	0.17	0.16
Calcium as CaO	19.70	19.70	7.90	7.96	21.80	21.65
Magnesium as MgO	2.11	2.07	2.66	2.76	2.28	2.11
Sodium as Na_2O	1.04	1.18	1.22	1.20	1.36	1.42
Potassium as K_2O	0.46	0.50	0.52	0.58	0.82	0.90
Water, Crystallization	4.40	4.49	3.90	3.64	4.10	4.25
Water, Hygroscopic	2.91	2.98	2.08	1.99	2.56	2.67
Carbonates, as CO_2	13.32	13.31	4.00	3.94	15.06	14.85
Ignition Loss (950°C)	20.22	20.26	8.75	8.78	21.76	21.76

REMARKS: *Fresh tuffaceous limestone.
**Slightly weathered siliceous shale.
***Fresh tuffaceous limestone.

REPORTED BY: ☐ PHONE ☐ WIRE
DATE:
TESTED BY: DW
CHECKED BY: DW
SAMPLED BY:

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MARIETTA, GEORGIA

DISTRICT: Jacksonville
PROJECT: Route 17, Interoceanic Canal Study
CONTRACT NO.:

GENERAL TEST REPORT

(ROCK CORES)

DATE REPORTED: 5 July 1968
WORK ORDER NO.: 4965
REQN. NO.: 08-123-ENG-108-68C
BASE UNIT COST:
DATE SAMPLE RECEIVED:
LAB NO.: See below

DESCRIPTION: See below
SOURCE: See below
FOR USE AS:
TESTED FOR: Chemical Analysis (% by wt.)

☐ MEETS SPECIFICATIONS ☐ FAILS SPECIFICATIONS (See below)

Lab No.	1M1073		1M1328	
Core Hole	17-CH-12		17-CH-12	
Depth (ft.)	288-291		383-384	
Rock Type	5*		5**	
Run	A	B	A	B
Silicon as SiO_2	44.96	45.10	42.46	42.64
Aluminum as Al_2O_3	18.62	18.39	16.88	16.36
Iron as Fe_2O_3	9.53	9.69	9.77	9.85
Manganese as MnO	0.11	0.11	0.13	0.13
Titanium as TiO_2	0.50	0.50	0.40	0.41
Phosphorous as P_2O_5	0.06	0.11	0.00	0.03
Calcium as CaO	9.98	9.90	9.67	9.52
Magnesium as MgO	6.45	6.31	8.88	8.88
Sodium as Na_2O	1.52	1.32	0.74	0.84
Potassium as K_2O	0.32	0.28	0.00	0.00
Water, Crystallization	4.54	4.49	5.51	5.70
Water, Hygroscopic	4.26	4.46	6.44	6.50
Carbonates as CO_2	0.26	0.26	0.14	0.20
Ignition Loss (850°C)	7.34	7.24	10.74	11.16

REMARKS: *Agglomerate.
**Agglomerate with tuffaceous matrix.

REPORTED BY: ☐ PHONE ☐ WIRE
DATE:
TESTED BY: DW
CHECKED BY: DW
SAMPLED BY:

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GENERAL TEST REPORT

(ROCK CORES)

DATE REPORTED: 5 July 1968
WORK ORDER NO.: 4965
REQN. NO.: 08-123-ENG-108-68C
BASE UNIT COST:
DATE SAMPLE RECEIVED:
LAB NO.: See below

DESCRIPTION: See below
SOURCE: See below
FOR USE AS:
TESTED FOR: Chemical Analysis (% by wt.)

☐ MEETS SPECIFICATIONS ☐ FAILS SPECIFICATIONS (See below)

Lab No.	1M1262 & 1M1264		1M1281		1M1315		1M1379 & 1M1381	
Core Hole	17-CH-12		17-CH-12		17-CH-12		17-CH-15	
Depth (ft.)	117-118		180-182		970		418-419	
Rock Type	6*		6***		6*		6**	
Run	A	B	A	B	A	B	A	B
Silicon as SiO_2	48.96	49.26	47.64	47.62	50.80	50.84	42.62	42.72
Aluminum as Al_2O_3	15.34	15.62	16.98	17.19	18.90	19.08	13.24	13.42
Iron as Fe_2O_3	9.37	9.37	9.13	8.97	7.53	7.44	6.25	6.01
Manganese as MnO	0.09	0.09	0.08	0.07	0.13	0.05	0.13	0.18
Titanium as TiO_2	0.48	0.46	0.45	0.45	0.06	0.08	0.40	0.39
Phosphorous as P_2O_5	0.06	0.12	0.04	0.06	0.01	0.02	0.04	0.00
Calcium as CaO	8.50	8.42	7.14	7.00	6.26	6.28	10.76	10.68
Magnesium as MgO	4.93	5.20	4.34	4.27	3.59	3.40	2.71	2.63
Sodium as Na_2O	1.40	0.94	1.28	1.12	3.00	2.75	1.48	1.50
Potassium as K_2O	0.36	0.28	0.48	0.40	0.60	0.45	0.56	0.46
Water, Crystallization	3.66	3.56	5.78	6.02	4.46	4.76	8.46	8.52
Water, Hygroscopic	6.34	6.46	6.46	6.34	3.50	3.75	5.48	5.38
Carbonates as CO_2	0.20	0.20	0.21	0.24	0.40	0.34	7.05	7.17
Ignition Loss (850°C)	9.28	9.36	11.00	11.04	7.31	7.56	19.36	19.32

REMARKS: *Fresh tuffaceous sandstone.
**Fresh calcareous tuffaceous sandstone.
***Fresh tuffaceous siltstone

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U. S. ARMY ENGINEER DIVISION LABORATORY, SOUTH ATLANTIC CORPS OF ENGINEERS MARIETTA, GEORGIA	DISTRICT: Jacksonville PROJECT: Route 17, Interoceanic Canal Study CONTRACT NO.
GENERAL TEST REPORT (ROCK CORES)	DATE REPORTED: 31 July 1968 WORK ORDER NO.: 4965
DESCRIPTION: See below	REQN. NO.: 08-123-ENG-108-68C
SOURCE: See below	BASE UNIT COST
FOR USE AS:	DATE SAMPLE RECEIVED
TESTED FOR: Chemical Analysis (% by weight)	LAB NO.: See below

☐ MEETS SPECIFICATIONS ☐ FAILS SPECIFICATIONS (See below)

Lab. No.	LM 1089		LM1093	
Core Hole	17-CH-7		17-CH-7	
Depth (ft.)	104-107		652-654	
Rock Type	7*		7**	
Run	A	B	A	B
Silicon as SiO_2	47.76	47.58	44.98	45.42
Aluminum as Al_2O_3	15.40	15.53	14.10	13.99
Iron as Fe_2O_3	10.65	10.57	10.49	10.57
Manganese as MnO	0.14	0.14	0.13	0.15
Titanium as TiO_2	0.56	0.60	0.51	0.54
Phosphorus as P_2O_5	0.01	0.00	0.01	0.01
Calcium as CaO	12.38	12.38	13.74	13.64
Magnesium as MgO	8.35	8.53	8.94	9.00
Sodium as Na_2O	1.62	1.64	1.52	1.52
Potassium as K_2O	0.14	0.12	0.14	0.14
Water Crystallization	3.37	3.72	5.92	5.72
Water, Hygroscopic	0.12	0.06	0.26	0.26
Carbonates as CO_2	0.11	0.07	0.00	0.00
Ignition Loss (950°C)	2.18	2.12	4.34	4.34

REMARKS:
*Slightly weathered and altered diabase.
**Slightly weathered altered diabase.

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U. S. ARMY ENGINEER DIVISION LABORATORY, SOUTH ATLANTIC
CORPS OF ENGINEERS
MARIETTA, GEORGIA

DISTRICT: Jacksonville
PROJECT: Route 17, Interoceanic Canal Study
CONTRACT NO.:

GENERAL TEST REPORT

(ROCK CORES)

DATE REPORTED: 31 July 1968
WORK ORDER NO.: 4965
REQN. NO.: 08-123-ENG-108-68C
BASE UNIT COST:
DATE SAMPLE RECEIVED:
LAB NO.: See below

DESCRIPTION: See below
SOURCE: See below
FOR USE AS:
TESTED FOR: Chemical Analysis (% by weight)

☐ MEETS SPECIFICATIONS ☐ FAILS SPECIFICATIONS (See below)

Lab. No.	1M1411		1M1419		1M1113		1M1405	
Core Hole	17-CH-11		17-CH-11		17-CH-11		17-CH-21	
Depth (ft.)	85-86		497-499		897-899		150-155	
Rock Type	*		**		***		****	
Run	A	B	A	B	A	B	A	B
Silicon as SiC_2	46.12	45.88	47.16	47.04	45.44	45.42	50.34	50.57
Aluminum as Al_2O_3	16.72	16.42	17.68	17.77	18.94	18.84	16.03	16.28
Iron as Fe_2O_3	7.77	7.69	9.05	9.05	9.13	9.29	8.25	8.09
Manganese as MnO	0.14	0.13	0.13	0.12	0.10	0.10	0.12	0.12
Titanium as TiO_2	0.56	0.65	0.45	0.45	0.44	0.49	0.31	0.36
Phosphorus as P_2O_5	0.01	0.02	0.01	0.01	0.09	0.10	0.11	0.10
Calcium as CaO	9.47	9.40	9.77	9.67	8.39	8.37	6.60	6.65
Magnesium as MgO	11.29	11.16	4.26	4.47	5.78	5.69	7.52	7.56
Sodium as Na_2O	1.72	1.80	1.56	1.48	1.40	1.48	1.60	1.73
Potassium as K_2O	0.06	0.06	0.08	0.10	0.12	0.14	0.84	0.81
Water, Crystallization	5.73	5.82	9.91	9.82	9.92	9.40	6.34	5.82
Water, Hygroscopic	1.24	1.16	0.40	0.38	0.90	1.10	2.22	1.91
Carbonates as CO_2	0.00	0.11	0.30	0.21	0.05	0.15	0.17	0.12
Ignition Loss (850°C)	5.32	5.48	8.84	8.84	9.24	9.40	6.60	6.55

REMARKS: *Fresh to slightly weathered diabase.
**Porphyritic amygdaloidal altered and slightly weathered basalt.
***Altered and weathered porphyritic basalt.
****Altered porphyritic basalt.

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U. S. ARMY ENGINEER DIVISION LABORATORY, SOUTH ATLANTIC
CORPS OF ENGINEERS
MARIETTA, GEORGIA

DISTRICT: Jacksonville
PROJECT: Route 17, Interoceanic Canal Study
CONTRACT NO.:

GENERAL TEST REPORT

(ROCK CORES)

DATE REPORTED: 31 July 1968
WORK ORDER NO.: 4965
REQN. NO.: 08-123-ENG-108-68C
BASE UNIT COST:
DATE SAMPLE RECEIVED:
LAB NO.: See below

DESCRIPTION: See below
SOURCE: See below
FOR USE AS:
TESTED FOR: Chemical Analysis (% by weight)

☐ MEETS SPECIFICATIONS ☐ FAILS SPECIFICATIONS (See below)

Lab. No.	141461 - 1465	
Core Hole	17-CH-15	
Depth (ft.)	276-277	
Rock Type	9*	
Run	A	B
Silicon as SiO_2	39.94	40.05
Aluminum as Al_2O_3	12.62	12.53
Iron as Fe_2O_3	5.77	5.77
Manganese as MnO	0.04	0.04
Titanium as TiO_2	0.27	0.28
Phosphorus as P_2O_5	0.06	0.08
Calcium as CaO	13.51	13.61
Magnesium as MgO	2.24	2.39
Sodium as Na_2O	1.60	1.64
Potassium as K_2O	1.10	1.10
Water, Crystallization	9.43	9.67
Water, Hygroscopic	3.16	3.18
Carbonates as CO_2	8.56	8.27
Ignition Loss (850°C)	20.70	20.56

REMARKS: *Fresh calcareous tuff.

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U. S. ARMY ENGINEER DIVISION LABORATORY, SOUTH ATLANTIC CORPS OF ENGINEERS MARIETTA, GEORGIA	DISTRICT: Jacksonville PROJECT: Route 17, Interoceanic Canal Study CONTRACT NO.
GENERAL TEST REPORT (ROCK CORES)	DATE REPORTED: 31 July 1968 WORK ORDER NO.: 4965
DESCRIPTION: See below	REQN. NO.: 08-123-ENG-108-68C
SOURCE: See below	BASE UNIT COST
FOR USE AS:	DATE SAMPLE RECEIVED
TESTED FOR: Chemical Analysis (% by weight)	LAB NO.: See below

☐ MEETS SPECIFICATIONS ☐ FAILS SPECIFICATIONS (See below)

Lab. No.	1M1475		1M1117		1M1131	
Core Hole	17-CH-11		17-CH-14		17-CH-14	
Depth (ft.)	926-929		577-578		600-604	
Rock Type	10*		10**		10***	
Run	A	B	A	B	A	B
Silicon as SiO_2	52.46	52.50	48.30	48.78	48.84	48.94
Aluminum as Al_2O_3	15.81	15.74	14.90	14.83	14.41	14.47
Iron as Fe_2O_3	10.09	10.09	6.89	6.93	7.45	7.45
Manganese as MnO	0.13	0.12	0.15	0.14	0.14	0.11
Titanium as TiO_2	0.58	0.58	0.46	0.50	0.56	0.51
Phosphorus as P_2O_5	0.05	0.07	0.10	0.10	0.10	0.10
Calcium as CaO	7.47	7.49	8.43	8.22	7.67	7.62
Magnesium as MgO	4.22	4.27	4.69	4.24	4.78	4.87
Sodium as Na_2O	1.32	1.40	1.12	1.16	1.08	1.24
Potassium as K_2O	0.40	0.46	1.00	1.04	1.20	1.36
Water, Crystallization	7.71	7.67	6.42	6.48	6.91	6.98
Water, Hygroscopic	0.20	0.25	4.22	4.32	3.74	3.76
Carbonates as CO_2	0.09	0.09	2.49	2.37	2.30	1.93
Ignition Loss (850°C)	6.40	6.40	11.74	11.75	11.86	11.92

REMARKS: *Fresh altered tuff.
**Fresh tuff.
***Interbedded tuffaceous agglomerate and sandstone.

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	PROJECT Route 17, Interoceanic Canal Study
	CONTRACT NO.
GENERAL TEST REPORT (ROCK CORES)	DATE REPORTED 31 July 1968
	WORK ORDER NO. 4965
DESCRIPTION See below	REQN. NO. 08-123-EIC-108-68C
SOURCE See below	BASE UNIT COST
FOR USE AS:	DATE SAMPLE RECEIVED
TESTED FOR: Chemical Analysis (% by weight)	LAB NO. See below

☐ MEETS SPECIFICATIONS ☐ FAILS SPECIFICATIONS (See below)

Lab. No.	IM1147-IM1144	
Core Hole	17-CH-14	
Depth (ft.)	489-491	
Rock Type	11*	
Run	A	B
Silicon as SiO_2	48.07	48.00
Aluminum as Al_2O_3	16.32	16.42
Iron as Fe_2O_3	7.85	7.77
Manganese as MnO	0.10	0.11
Titanium as TiO_2	0.50	0.53
Phosphorus as P_2O_5	0.07	0.07
Calcium as CaO	8.30	8.25
Magnesium as MgO	6.12	6.14
Sodium as Na_2O	1.28	1.40
Potassium as K_2O	0.56	0.64
Water, Crystallization	5.31	5.12
Water, Hygroscopic	6.26	6.42
Carbonates as CO_2	0.00	0.00
Ignition Loss (850°C)	9.38	9.36

REMARKS: *Slightly weathered lapilli tuff.

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U. S. ARMY ENGINEER DIVISION LABORATORY, SOUTH ATLANTIC
CORPS OF ENGINEERS
MARIETTA, GEORGIA

DISTRICT: Jacksonville
PROJECT: Route 17, Interoceanic Canal Study
CONTRACT NO.:

GENERAL TEST REPORT

(ROCK CORES)

DATE REPORTED: 31 July 1968
WORK ORDER NO.: 4965
REQN. NO.: 08-123-ENG-108-680
BASE UNIT COST:
DATE SAMPLE RECEIVED:
LAB NO.: See below

DESCRIPTION: See below
SOURCE: See below
FOR USE AS:
TESTED FOR: Chemical Analysis (% by weight)

☐ MEETS SPECIFICATIONS ☐ FAILS SPECIFICATIONS (See below)

Lab. No.	LM1317	
Core Hole	17-CH-22	
Depth (ft.)	1443	
Rock Type	12*	
Run	A	B
Silicon as SiO_2	43.28	43.52
Aluminum as Al_2O_3	11.58	12.15
Iron as Fe_2O_3	7.98	7.40
Manganese as MnO	0.14	0.13
Titanium as TiO_2	0.74	0.70
Phosphorus as P_2O_5	0.11	0.10
Calcium as CaO	7.20	7.22
Magnesium as MgO	10.48	10.25
Sodium as Na_2O	0.55	0.55
Potassium as K_2O	0.60	0.65
Water, Crystallization	8.91	8.52
Water, Hygroscopic	7.11	7.13
Carbonates as CO_2	0.76	0.59
Ignition Loss (850°C)	15.02	14.65

REMARKS: *Fresh altered tuff

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